FINAL REPORT

Craigleith Wastewater Pumping Station Optimization Study

21-2028

April 7, 2022

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REPORT SNAPSHOT

Project Snapshot is a WT Infrastructure Solutions Inc. initiative to communicate the five to ten key pieces of information that are important for the reader to take away from the report. It is not intended to replace a comprehensive review of the report.

- This project has the objective to support the upgrading and renovating of the Craigleith SLS. Therefore, a review of the Process Systems and related Controls, building system and Process Equipment was conducted with the intent to provide recommendations to maximize future efficiency of Craigleith Wastewater Pumping Station as well as equipment standardization throughout the Town's facilities.
- A review of the building areas and assessment of the Electrical Area Classifications indicates that to meet the National Fire Protection Association requirements under the current arrangement, the separation of the Dry Well from the ground floor operations and electrical equipment space is the most efficient method of reducing the heating energy efficiency while achieving the area classification for the electrical distribution equipment. The estimated cost of this upgrade is $340,350 +/- 25%.
- The energy audit indicates that the sewage pumping operation represents 63% of the energy consumed at the Craigleith SLS. Significant energy savings may be achieved through upgrading the sewage pumping operations which the selection of pumps that achieve a minimum of 60% overall efficiency under the average flow conditions.
- Upgrading the building ventilation and associated heating requirements will achieve improvements in energy consumption with an overall expectation that a 40% energy efficiency is achievable for the facility.
- Most of the existing electrical equipment is near to the design life and needs to be replaced. The estimated cost of this is $1.38M +/-25%.
- Septage and Leachate are received at the facility in significant amounts which are likely the largest source of odours at the facility. In the short-term, the Septage/Leachate discharge pipe should be extended below the water level in the entrance channel to the SLS.
- If all of the recommended upgrades are completed, the estimated total capital cost will be $4.53M +/-25% and the total energy efficiency opportunities will result in a savings of approximately greater than 50% of the energy use and approximately 82,800 fewer kW of energy consumed per year.

April 7, 2022

Town of the Blue Mountains
32 Mill Street, P.O. Box 310
Thornbury, ON, N0H 2P0

Re: Final Report
Craigleith Wastewater Pumping Station Optimization Study
21-2028 | VERSION 2

WT Infrastructure Solutions Incorporated (WT) is pleased to submit the following report as part of the project delivery for the Craigleith Wastewater Pumping Station Optimization Study.

In accordance with the project schedule, we have allowed for ten (10) days for client review and comments. Please let us know if you need additional time or have any questions regarding this document. We look forward to your comments and the opportunity to advance this project to completion

Respectfully submitted,

WT INFRASTRUCTURE SOLUTIONS INCORPORATED

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1 INTRODUCTION

This Optimization Study report is a combined effort by WT Infrastructure and EVB Engineering on behalf of the Town of the Blue Mountains intended to review the existing process mechanical and electrical equipment in service at the Craigleith Main Sewage Lift Station (SLS) and provide optimization recommendations for future upgrades.

The Craigleith SLS is located on Lakeshore Road East, Town of Blue Mountain and was originally constructed and commissioned in 1985. The SLS is currently operated under Amended Certificate of Approval # 6412-6FHR7G (Caffa). The Caffa indicates that the station has a design peak flow capacity of 180 L/s.

The SLS is the main lift station for all the sanitary collection system servicing the Craigleith area and is the sole SLS discharging sewage to the Craigleith Sewage Treatment Plant. The existing pumping station is serviced by two (2) 100 hp pumps each with an original design capacity of 122 L/s at 36 m total dynamic head (TDH). The SLS includes an inlet grinder, dual wet-well, an existing out-of-service odour control system using sodium hypochlorite dosing to the wet well, variable frequency drives for pump controls. The system has a 200-kW diesel generator and automatic transfer switch providing back-up power for the system.

The Town has implemented an Energy Conservation and Management Plan which has a target of reducing corporate greenhouse gas (GHG) emissions to 40% below 2005 levels by 2025 and achieving carbon neutrality by 2050. This project has the capacity to contribute to Town objectives through system optimization and energy efficiency.

1.1 Project Objectives

The objective of this undertaking is to support the upgrading and renovating of the Craigleith SLS including optimizing the energy consumption of the facility. The objectives of this undertaking are:

- Review the Process Mechanical and Electrical equipment servicing the SLS and conduct a comprehensive audit of the Process-Related Equipment
- Review the building areas and assess the Electrical Area Classifications and required building modification to meet the relevant Code requirements
- Investigate the monitor and assess the energy systems, review energy conservation opportunities
- Develop recommendations for Process improvements and energy conservation opportunities

The outcomes of this project will allow the Town to develop tailored yet consistent approaches to the monitoring, operations, and energy management at the pumping station. This will ensure that the facility can deliver consistent flow to the Craigleith Water Pollution Control Plant in a manner that reflects the Town values in terms of efficiency and sustainability. Furthermore, the optimization will inform future proposed upgrades to maximize future efficiency of Craigleith Wastewater Pumping Station as well as equipment standardization throughout the Town's facilities.

2 TECHNICAL MEMO SUMMARY

The project reporting has been developed based on the following series of technical memorandum (TM) prepared to document and detail the current operations, summarizing the technical information. These TMs are attached to this report in the Appendices and the executive summaries and salient information from each is presented in the subsequent sections.

The Technical Memorandum prepared for this project include:

- TM #1: Building Area Classification and Ventilation Review

- TM #2: Process Mechanical Review
- TM #3: Energy Audit & Renewables Review
- TM #4: Electrical Equipment Review
- TM #5: Process Control Narrative
- TM #6: Septage Receiving Station

As indicated, each TM is summarized below, and the resulting conclusions and recommendations are provided. The reader is directed to the individual TM (Appendix) for specific information on each topic.

2.1 Technical Memo #1: Building Area Classification and Ventilation Review

The Craigleith Main SLS is comprised of two process areas: Wet Well and Dry Well. The electrical area classifications for these sewage works are dictated by National Fire Protection Association (NFPA) 820, *Standards for Fire Protection in Wastewater Treatment and Collection Facilities 2020 Edition*. These areas are classified as:

Wet Well is classified as Class 1, Division 1 Group D, requiring continuous ventilation at 12 air changes per hour and gas detection (atmospheric O_2 and less than LEL H_2S) required for infrequent occupancy of the confined space for maintenance. The wet well space has a volume of approximately 362 m^3, requiring 1,200 L/s to achieve the twelve (12) air changes. Currently the space is provided with two supply fans each provide a design rated capacity of 1,100 L/s at 38 mm water column. As such, with a two-fan operation the ventilation rate is approximately double the required rate.

The NFPA code requires exhaust fans (not supply) for process facilities not routinely entered by personnel otherwise both supply and exhaust fans are required. Furthermore, during occupancy the existing supply fans draw fresh air from the air space above the wet well access hatches, essentially recirculating the air when these hatches are open.

Dry Well is unclassified provided the entire space has a minimum of six (6) continuous air changes per hour. This includes the entire below grade and above grade electrical equipment spaces as there is no physical separation between these spaces. If less than 6 air changes per hour is provided, the electrical rating changes to Class 1 Division 2 Group D. Currently, the main ventilation system is designed to draw air either from outside or inside depending on the outside temperature, discharge the "fresh air" to the below grade dry well, which would they flow into the space and up through the open grating in the floor about that space. Currently there is only one exhaust air damper servicing the Dry Well and operations floor area, which is the damper associated with the Generator air inlet and is typically closed at temperatures less than 25°C. As such, during most operating conditions the air is recirculating within the operations space.

To meeting the NFPA requirements under the current arrangement, the outdoor air should be discharged into the dry well space and the exhaust louvre open continuously to ensure fresh air is provided and circulated through the entire area. This air would require heating which would represent a major source of wasted energy.

To evaluate the most effective/efficient design the following options should be reviewed:

1) All electrical equipment rated to Class 1 Division 2 Group D, with ventilation and monitoring to address health and safety of the air space and building climate controls.
2) Providing continuous outside supply air at six (6) air changes per hour, including necessary air heating, serviced by a supply and exhaust fan (this should be discussed further as the code does provide leeway for "not routinely entered spaces").

3) Construction of an air lock to isolate the below grade Dry Well from the above grade operations floor which will de-classify the operations area, then address the classified area with the following options

   a) De-classify the Dry Well area as per 2 above.

   b) Provide Class 1 Division 2 Group D equipment in the Dry Well space only.

   c) Provide gas detection including alarming and intermittent ventilation based on occupancy with item 3b.

Option 3 is the most energy efficient option for building heating and ventilation as well as from an electrical equipment classification perspective.

2.2 Technical Memo #2: Process Mechanical Review

The process equipment servicing the Craigleith SLS consists of the two (2) 100 HP dry well shafted centrifugal pumps and motors located at grade. The pumps include isolation valves, discharge check valves and appurtenances. The existing sewage pumps consist of the following:

- Arora 612 A 6"x8"x18" (8" inlet, 6" outlet, 18" maximum impeller diameter)
- Actual impeller: 446 mm
- Rated Capacity: 120 L/s @ 36.34 m TDH
- Rated Speed: 1150 rpm @ 60 Hz
- Maximum Efficiency at Rated Capacity: 77.51% (mechanical)
- Flow at the Best Efficiency Point: 144.6 L/s
- Minimum Continuous Stable Flow (MCSF): 44.15 L/s

The suction piping consists of an arrangement of 350 mm diameter stainless steel wet well suction piping, reducing to the 200 mm pump inlet. Pump No. 1 draws sewage from the north wet well whereas Pump No. 2 draws sewage from either the north or south wet wells.

The discharge piping from each individual pump consists of a 150 mm discharge, expanding to 200 mm which discharges to a common 300 mm header, through a magnetic flow meter, which then is split through a fabricated wye fitting, reducing to 200 mm into each of the 2,200 m existing force mains. A full bonnet isolation gate valve is provided to isolate each of the force mains. Each of the force mains increases from the 200 mm connection points inside the station to 300 mm via a 200→300 mm reducing fitting outside of the station, underground.

Each of the force mains includes a 200 mm drain piping, isolation gate valves and discharge through a combined outlet into the north wet well. Outside of the station, located on each of the force mains are 300 mm isolated by-pass connections which enable isolate of the pumping station and direct connections with each forcemain.

The system hydraulic boundaries are defined according to the following physical characteristics:

- Discharge Elevation at the Craigleith WWTP: 185.55 m (Liquid Level at Headworks Inlet)
- SLS High Water Level: 174.00 m (Transducer Max Level)
- SLS Low Water Level: 172.2 m (LWL Shut-off)

There is a collection system overflow; however, the elevation of the overflow is not well defined. Coordination of the overflow and the elevation of the lower sanitary collection system connections should be identified to eliminate and/or reduce any system surcharging and define the operational limits of the system.

The two 300 mm Ø force mains can operate in parallel or in isolation, under the physical operating boundaries identified.

2.2.1 Single Forcemain

A single forcemain operation can achieve a flow range of approximately < 30 L/s @ 10.5 m TDH (30 Hz) to ~112 L/s @ 36.5 m TDH) with a single pump operating at 60 Hz. With the additional of the second pump, the parallel pump operation at 60 Hz increased the maximum flow to approximately 125 L/s @ 42 m TDH. This is about a 13 L/s increase in total discharge flow rate due to the substantial increase in dynamic head loss between the two scenarios.

2.2.2 Parallel Forcemains

Parallel forcemain operation results in an increase in the capacity of both the single and parallel pump operation due to the reducing in forcemain velocity. The flow and head range of the system in a single pump operation extends from less than 30 L/s @ 10.5 m TDH (30 Hz) to 165 L/s @ 30.5 m TDH (60 Hz). The dual pump operation increases the total system capacity to 218 L/s @ 38.5 m TDH (60Hz) based on the high-water level elevation identified above. There have been situations where the high-water level was exceeded due to pump failures and other electrical system failure which have resulted in short duration flows of approximately ± 240 L/s which is possible if the high-water level increases to a sewer surcharge condition leading to sewer backups. Based on the operating record, there are no sustained inflows of this magnitude.

2.2.3 Forcemain: Operating Velocities and Ultimate Capacity

The velocity analysis provided below is focused on the 2,200 m long 300 mm diameter forcemains as they represent the next largest contributor to the total dynamic head of the system. According to the MECP Design Guidelines, the velocities should be in the range of 0.8 to 2.5 m/s with the lower limit being preferred for the initial build out of the service area. These velocities are recommended to prevent sediment build up, ensure acceptable retention times and to avoid excessive transient pressure surges. Once the velocity starts to exceed the upper limit, the frequency of pipe failures increases.

The current operating velocities are:

- Single 300 mm diameter force main
    - 0.43 m/s @ 30 L/s
    - 1.617 m/s @ 112 L/s
- Parallel 300 mm diameter force mains
    - 0.22 m/s @ total flow of 30 L/s
    - 1.57 m/s @ total flow of 218 L/s

As indicated, the low flow condition results in velocities below the minimum recommended value. Ideal velocities are achieved at system flows greater than about 55 L/s with a single forcemain operation.

2.2.4 Current Operational Patterns

The system monitoring data includes the discrete level data available from the Ultrasonic level measuring units and the discrete flow metering data available from the magnetic flow meter. The data was made available by the system integrator ARO for the period of April 2020 to current (Flow) and June 2021 to current (level). The data indicates the following:

- The pumps operate above 20 L/s 97.4% of the time
- The pumps operate above 50 L/s 12.1% of the time.
- The pumps operate between 20-50 L/s 85.3% of the time.
- The pumps operate at their rated capacity (120L/s) < 0.3% of the time.

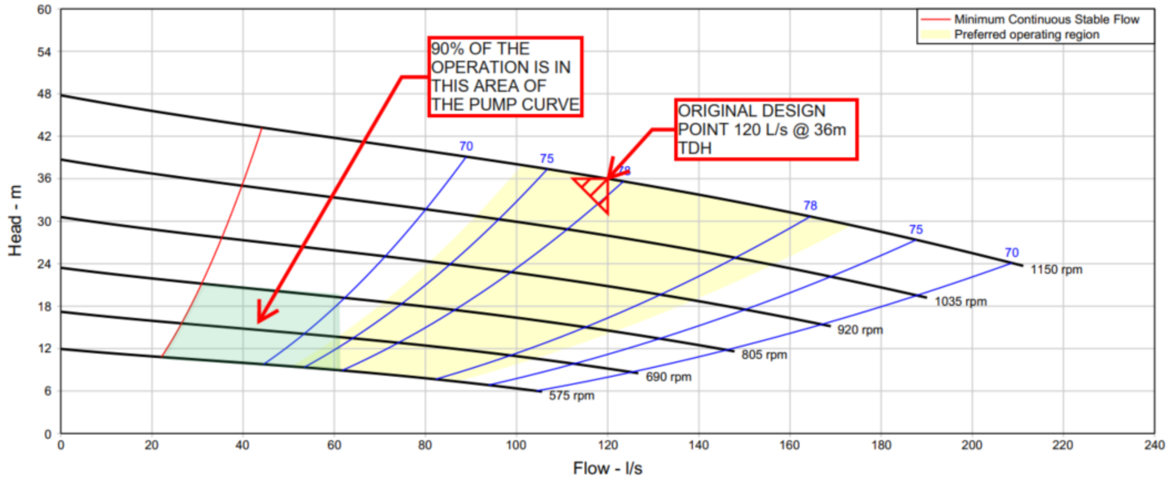


Figure 2-1: Arora 612 a Pump Curve

This analysis indicates that the pumps are not operating anywhere near their best efficiency point (Figure 2-1). Supplying the pumps through a VFD does allow the pump efficiency to be maintained over a wider range of flows however the pumps appear to be operating at the lower limits of there operating range. VFD and motor efficiency will also start to drop off under very lightly loaded conditions.

The Wire-to-Water (WTW) efficiency of the sewage pumping system relates to how effectively the system converts electrical power into hydraulic power. Essentially, a system with a higher wire-to-water efficiency will require less electrical energy (kWh) to pump the same volume of fluid.

The WTW efficiency is simply the pump efficiency multiplied by the motor efficiency and the variable frequency drive (VFD) efficiency at the pump operating point. It can be calculated as the hydraulic power output of the pump divided by the electrical power at the input of the VFD. An efficient pumping station should see WTW efficiencies of 60-70%.

To evaluate the WTW efficiency of the Craigleith SLS, electrical energy loggers were installed on the input to each pump VFD to measure the electrical energy consumed by each pump over a 30-day period (Oct. 14, 2021 – Nov. 13, 2021). The energy data was aligned with system flow data recorded in the SCADA historian over the same period. Hydraulic system pressures were approximated based on the calculated system curves. The WTW efficiency will vary with flow (L/s) and pump arrangement.

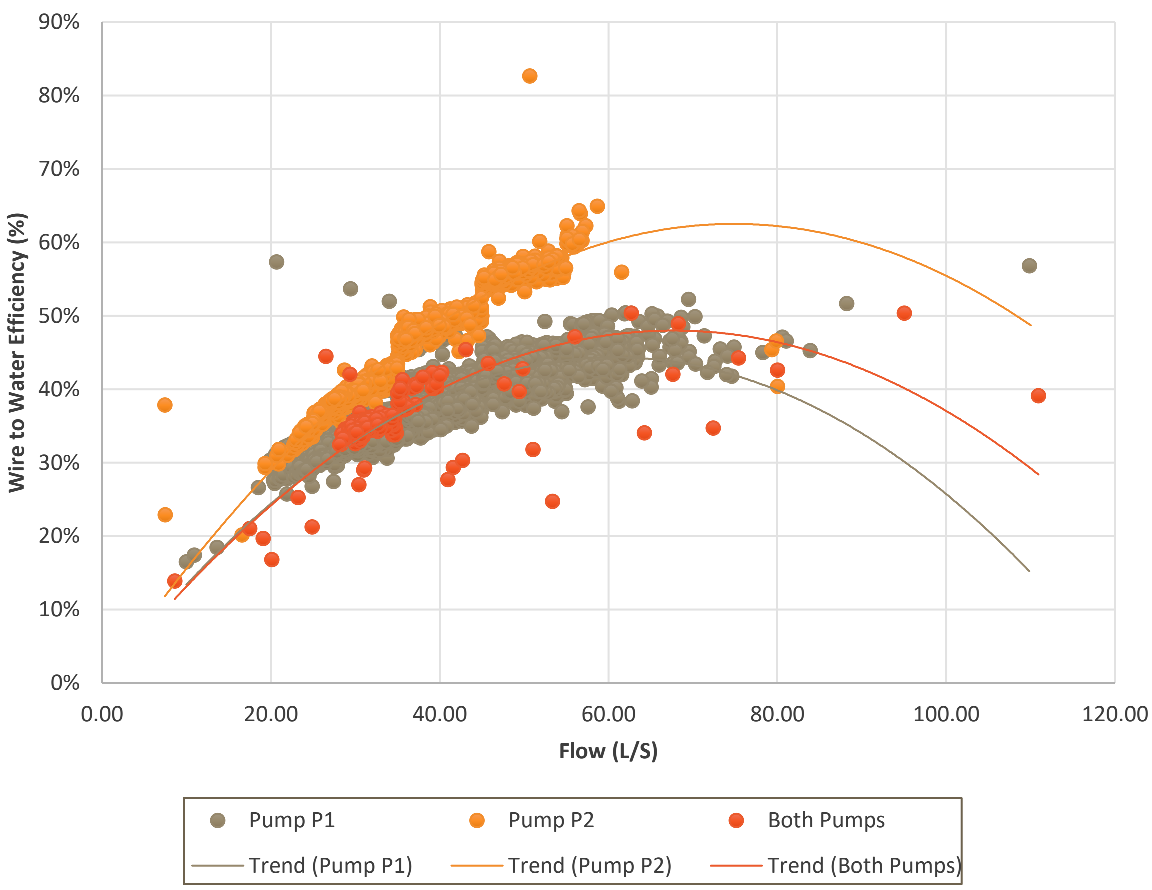


Figure 2-2: Wire-To-Water Efficiency (Oct.14 – Nov.13)

From the Figure 2-2 curve, we can make the following observations:

- The best efficiency point for the system occurs beyond 60 L/s. The efficiency drops off significantly below 60 L/s.
- The WTW efficiency of the system generally ranges between 20-65% with an average calculated WTW efficiency of 40%.
- Sewage pump P2 operates more efficiently the sewage pump P1.
- Sewage pump P2 provides are more predictable and consistent output for a given electrical input.
- Both pumps operate at system flows below 80 L/s at a very low WTW efficiency.
- There is considerable room for improved efficiency and energy conservation.

As expected, we can see that the pumps are operating well below their best efficiency point. The pump, VFD and motor efficiency all begin to suffer under lightly loaded conditions which makes for a very inefficient pumping arrangement. It is interesting to note that the pump P2 performs more efficiently than pump P1. It was noted that the VFD supplying P2 had been replaced with a modern PWM AC drive. Pump P1 is still being supplied by it's original VFD (1985 vintage). Improvements in VFD technology are likely showing up as improved efficiency and greater control over P2.

Interim efficiency gains could be had by simply reversing the duty cycle so that P2 operates more frequently than P1 until further pump upgrades are performed.

2.3 Technical Memo #3: Energy Audit & Renewables Review

2.3.1 Electrical Baseline

Based on historical utility metering, the Craigleith SLS consumes approximately 150,000 kWh of electricity on an annual basis. Figure 2-3: Electrical Energy Consumed by Load Group below provides a breakdown of the annual kWh consumption by the various loads within the SLS. These values were approximated by installing electrical energy loggers on the sewage pumps over a 4-week period. This metering data was used to estimate the historical kWh consumption from the pumps based on historical flow data captured from the SCADA system. The energy consumed by the ventilation system and basic building loads was estimated based on nameplate data and an assumed 24/7 operation. The remaining kWh were attributed to the building heating system. This model covered the 12-month period ranging from September 2020 to August 2021. Actual percentages may vary year over year depending on variations between flows through the SLS and heating demands but this figure provides insight into the relative contribution of each load group.

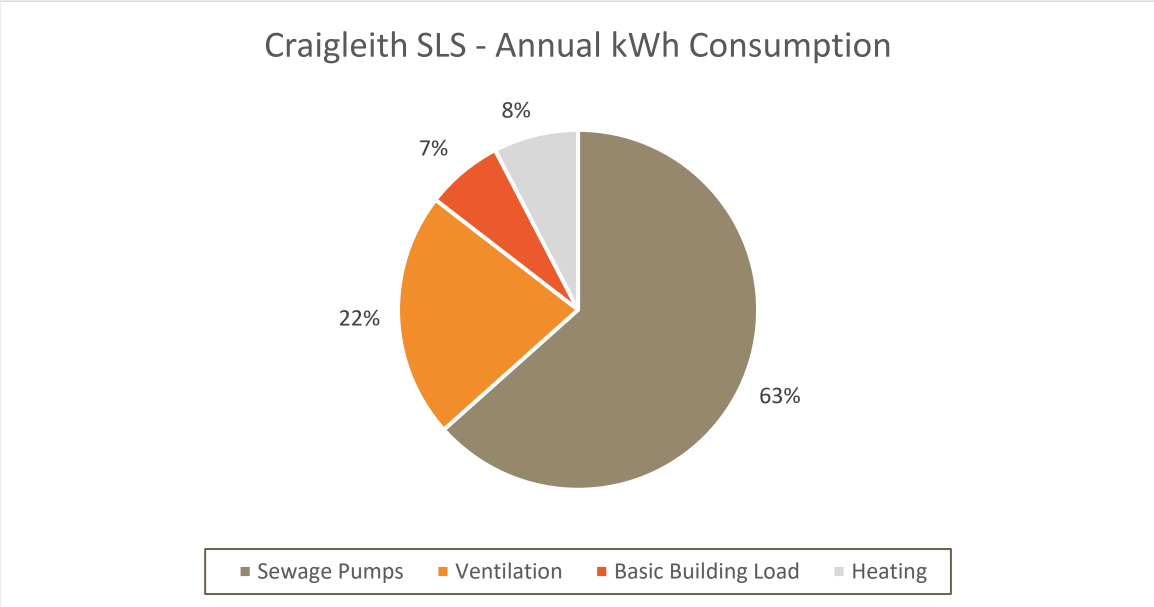


Figure 2-3: Electrical Energy Consumed by Load Group

2.3.2 Opportunities For Energy Conservation

The following opportunities should be considered as part of the planned sewage lift station upgrades to improve the overall efficiency of the site, conserve energy and reduce the overall “carbon footprint” of the site. With the implementation of these design changes, it can reasonably be expected to reduce the overall energy consumed by the facility by 40% or more. Table 2-1 summarizes where the potential efficiency gains for each of the load areas, the two main areas where significant energy efficiencies can be found are by increasing the pumping system and ventilation efficiencies, each are described in further detail below.

Table 2-1: Areas for Potential Energy Savings

Load Group	Current Electricity Baseline	Potential Savings (%)	Estimated Future Baseline
Sewage Pumps	95,097 kWh	33%	62,764 kWh
Ventilation System	33,113 kWh	>90%	3,311 kWh
Basic Building Loads	10,366 kWh	<1%	9,899 kWh
Heating System	11,436 kWh	50%	5,718 kWh
Total	**150,012 kWh**		**81,692 kWh**

Using the weighted average cost per kWH of 11.2 cents, the estimated potential savings would amount to $7,650 per year.

Sewage Pumps

As discussed previously, the existing sewage pumping system is very inefficient with an average wire-to-water efficiency of 40%. An efficient pumping system should see efficiencies in excess of 60%. Like for like replacement of the pumps is not recommended. The new pumps should be selected so that their best efficiency point occurs between 20-50 L/s under normal system operating conditions.

Increasing the system efficiency to 60% would result in a 33% reduction in energy consumed by the sewage pumps and 21% reduction in overall electrical energy consumed by the SLS.

Ventilation System

Technical Memo #1 reviewed the construction of an airlock to separate the dry well from the operation area of the building. This was proposed based on the area classifications and the effectiveness of the existing ventilation system as well as to reduce the amount of waste energy to heat the transient air flow; although we understand that the current ventilation system is recirculating the heated air, the NFPA requires the classified areas be provided with appropriately rated electrical equipment. The documented potential efficiency savings identified in Table 2-1 is more a reflection of the of the savings offered between items 2 and 3 identified in TM #1.

By providing a physical separation between the dry well and operations area, continuous ventilation of the dry well would not be required which would virtually eliminate the existing ventilation demands for the building. The dry well could be provided with intermittent ventilation based on occupancy only. The electrical equipment within the drywell would be replaced with equipment rated to Class 1 Division 2 Group D and all other equipment rated for installation in an unclassified area.

For the purposes of this analysis, it is conservatively assumed that this would result in a minimum 90% reduction in energy consumed by the ventilation systems which corresponds to a 20% reduction in overall electrical energy consumed by the SLS on annual basis.

2.3.3 Energy Offset Opportunities

This project has the capacity to contribute to Town objectives for the Energy Conservation and Management Plan through system optimization and energy efficiency. As identified in the project RFP, the goal was to project is to supply 50% of the building power with renewable energy working towards a net zero ready building. There is opportunity to potentially achieve a 50% reducing in the power consumption though increased pumping efficiency, reducing in heating and ventilation demands and offsetting the energy required for the base building loads.

Opportunities for energy and carbon reductions include:

1. Building Envelope Upgrades: Upgrading Exterior Wall Profiles, Roofing Systems, Windows, and Doors
2. Heat Recovery Systems, Heating and Cooling System Replacement
3. Solar PV Installation to Offset Energy Consumption
4. Lighting System Retrofit
5. Fuel Switching

We understand that the SLS has undergone a recent building façade upgrade including siding and roofing, as such there are few potential upgrades to identify in Item 1. Items 2 and 3 are the areas that represent significant opportunities to offset the building base energy and heating loads. Depending on the preferred option selected for the building arrangement, the ventilation system could include a heat recovery system and could include a ground source heat pump for trim heating using a hydronic system. The design loads and sizing are beyond the scope of the current undertaking due to the unknowns of the preferred configuration; however, the Solar Photovoltaic (PV) arrangement has been developed based on the roofing area available on the existing building. Further development of the PV option for ground mounted systems was not developed due to the limited land area of the site and the proximity of the future development abutting the southern boundary of the site.

Solar - Photovoltaic

The single sloped, South facing roof of the Craigleith SLS lends itself as an ideal location for a rooftop photovoltaic (PV) solar array. The existing roof provides approximately 120m^2 of surface are for installation of PV modules however, accounting for existing roof and building vent penetrations and allowing a 1m working space around the perimeter of the array, it can conservatively be expected to provide a minimum of 60m^2 of PV coverage. Modern PV modules provide efficiency of 20% or more. 60m^2 of PV modules would provide up to 12kW of electrical power. This array would match nicely with a 10kW inverter. Typically, PV array capacity is 20-30% larger than the inverter rating knowing that the PV output will not be operating at full capacity throughout the year.

The proposed system was modeled as a fixed mount system mounted with a tilt angle of 15^o (existing roof pitch) and an azimuth angle of -15^o. With this model, it was calculated that the proposed array would produce 14,583 kWh of energy on an annual basis. This would reduce the power cost at the facility on an annual basis by $1,633.

2.3.4 Energy Efficiency Funding Opportunities

There are several potential funding opportunities for energy efficiency measures that could be considered, including funds promoted by the Federation of Canadian Municipalities or utility-managed electricity programs. The following is a list of the available projects and are further detailed in the attached TM #3.

1. **Green Municipal Fund:** The Federation of Canadian Municipalities established the Green Municipal Fund in 2000 to drive local green innovation across the country.
   a) Capital Project: GHG Impact Retrofit.
   b) Capital Project: GHG Reduction Pathway Retrofit
   c) Retrofit of municipal facilities
   d) New construction of energy efficient municipal facilities
2. **Save On Energy – Retrofit program**
3. **IESO: Grid Innovation Fund/OEB Innovation Sandbox**
4. **Investing in Canada Infrastructure Program - Green and Inclusive Community Buildings Program (GICB)**

2.4 Technical Memo #4: Electrical Equipment Review

2.4.1 Existing Power Distribution

Much of the existing electrical equipment is original to the station (c. 1985) and nearing its expected design life. With planned upgrades to the pumping arrangement and ventilation systems, it is recommended that all the existing distribution equipment be replaced rather than modified to suit the new systems. At a minimum, this will include the replacement of the main Motor Control Centre (MCC-1), both VFDs, the low voltage lighting panel (LP-A), the generator and the Automatic Transfer Switch (ATS). The existing utility service has sufficient capacity to support the future process upgrades; however, the location of the service entrance equipment should be relocated and as such, the service entrance conductors will be relocated and/or replaced as part of the distribution system upgrades.

2.4.2 New Power Distribution

Upgrades to the electrical distribution system should be included as part of the planned process upgrades at the Craigleith SLS. The new electrical distribution system will be based on the total load requirements of all equipment within the facility, and will provide system reliability, ease of maintenance and resilience. The general equipment specifications required for the following electrical equipment are provided in TM #4:

- Switchboard
- Utility Metering
- Customer Metering
- High Voltage (600 V) Distribution
- Surge Protection
- Emergency Generator
- Automatic Transfer Switch
- Low Voltage (120/208V) Transformer
- Low Voltage Distribution Panel
- Motors and VFDs
- Lighting Upgrades
- Grounding

A preliminary single line diagram (SLD) for the proposed distribution system is included in TM #4.

2.5 Technical Memo #5: Process Control Narrative

2.5.1 System Overview

The sewage lift pumps servicing the Craigleith SLS are powered through variable frequency drives (VFDs) which allows for flow control on the discharge piping. Under normal conditions, the PLC at this location is the primary device controlling the pumps. The discharge flow rate is regulated based on the level within the wet well and generally matches the inflow rate. The current pump configuration and setpoints are such that at least one pump runs continuously (>99% of time) throughout the year.

Instrument Arrangement

Level elements are provided within the wet well to provide continuous measurement and monitoring of the wet well levels for automatic control of the sewage lift pumps. An ultrasonic level element is installed within the North well and a hydrostatic pressure element is installed within the South well. This allows for redundant level measurement within the wet well. Operators can select which element they would like to use to control the pumps.

High-Level and Low-Level floats are provided within the North and South wells to provide backup operation of the pumps. Each pair of floats are wired in parallel to provide redundant control from either the North or South wet wells.

Modes of Operation

There are three (3) basic modes for operating the lift station: Local Manual Control, Remote Manual Control and Remote Auto Control; as well, the system is equipped with a backup mode of operating in the event of a PLC or automatic system control failure.

It is noted that the current SCADA controls and instrumentation is generally in acceptance in the industry. Including both an ultrasonic and hydrostatic element has become common practice and provides reliability from both a redundancy and technology perspective. It is recommended that the floats be replaced with Multitrode conductive level controllers mainly due to the failure and unreliable nature of the float switches. The Multitrode unit operates as a discrete level sensor, generally replacing the float switches in many municipalities.

Additionally, in order to monitor the energy consumption and efficiency of the SLS following the upgrades, the SCADA system should incorporate energy metering of both the incoming power as well as the individual pumping unit power metering and calculations of the real-time energy (kWh) per unit of sewage flow (kWh/m^3).

2.6 Technical Memo #6: Septage and Leachate Receiving Station

This section is intended to review and identify the potential impacts related to the disposal of leachate and septage at the Craigleith Wastewater Pumping Station.

2.6.1 Existing Receiving Station

The existing septage and leachate receiving station was added to the Pumping Station in 2009 and it is located at the western exterior wall of the facility. In particular,

- **The septage receiving station** is characterized by an analog screen data logger and control panel, a 100 mm diameter pipe with an electric actuated valve, magnetic flow meter and wall-mounted transmitter.
- **The leachate receiving station** is characterized by a 150 mm diameter pipe, without controls or flow measurements.

A review of background information suggested that the volume of septage is approximately a third of the volume of leachate. Specifically, the pumping station receive between 283 m^3/month to 1,553 m^3/month of septage, and 635 m^3/month to 5,506 m^3/month of leachate.

Both the septage and leachate are discharged through hatches into the wet well where a channel monster grinder is installed.

2.6.2 Challenges with the Existing Receiving Station

The following are the main challenges associated with the septage and leachate receiving station at the Craigleith Pumping Station:

1. **<u>Facility Site</u>**

The existing site is located approximately 100 m from the entrance on Lakeshore Road East and approximately 30 m from Highway 26. The site is bounded to the north by Highway 26, to the east by vacant treed property, to the south by the Georgian Trail and to the west by Lakeshore Road East. The property is generally flat and appears to be graded in a manner to promote surface drainage runoff; however, the main floor it is not raised up as high as would be desirable for drainage and to maximize gravity flow for an overflow. This is more of a preference rather than a deficiency.

Due to the location proximate to the Georgian Trail combined with the relative remoteness of the site from public view to Lakeshore or Highway 26, the site has a higher security risk of unauthorized access or vandalism. The absence of any fencing at the site is an issue related to security; however, due to the need for access to the building for the septage and receiving station does not allow for the installation of a comprehensive fencing system. If the septage and leachate receiving station is relocated to the Craigleith Wastewater Treatment Facility, then the opportunity to fully fence the site could be considered.

An additional factor related to the site is the visual impact from the Georgian Trail and the future land development area to the south. Currently, the facility is clearly visible and may not be considered the appropriate aesthetic for the area. An option to address this would be to plant a visual tree barrier between the facility and the trail. This will also reduce the likelihood of security issues because the facility would not be visible by the public. The addition of the tree barrier will also assist in the management of odour at the site. The estimated cost of the fencing and tree barrier would be approximately $75,000 +/- 25%.

The location of the existing driveway would indicate that the access was selected to avoid an entrance onto Highway 26 rather than for operational purposes. The access and egress from the site are complex due to the length and width of the driveway. Due to the layout, larger trucks will need to back in or out of the site, which will result in some safety concerns and would make multiple concurrent loads challenging. This is not preferred and is a significant driver in the relocation of the septage and leachate receiving station. Due to the proximity to the Lakeshore Road East and Fraser Crescent intersection and the curve on Highway 26, an option of an entrance directly onto Highway 26 may be difficult to secure permitting for, but it would be a preferred access.

The existing asphalt is deteriorating and is distressed in several areas. This is to be expected as the trucks entering the sites are heavily loaded and there is often a peak period of septic tank clean-outs in the spring when the frost heave can cause further subgrade damage. If there were a change to the use with the removal of the septage receiving station, the roadway could be slightly reconfigured to reflect the revised use; however, it will still need to be designed to meet the loading requirements associated with heavy maintenance vehicles. The estimated cost of rehabilitating the asphalt would be in the order of $75,000 - $125,000 +/- 25% depending on whether any of the base material could be reused.

2. **Access to the facility**

The existing Craigleith Main Lift Station is an exterior station located proximate to both current and future residential properties and near to the Highway 26 in a location where septage hauling vehicles need to complete relatively complex movements to navigate the site. Background information suggested that approximately 700 round trips are made annually by the haulage trucks to the Craigleith Pumping Station which results in a significant amount of traffic in the area. The truck traffic also impacts the Georgian Trail crossing in the vicinity of the facility. Furthermore, as the residential area to the south of the Craigleith pumping station is expected to increase, the truck traffic for the disposal of leachate would be a source of logistic difficulties in the area.

3. **Odour complaints.**

Septage has an offensive odor, and septage processing can release odors in the atmosphere. As the facility is designed to receive septage and leachate, given the current proximity of houses, this activity resulted in an increase in odour complaints. Although attempts have been made to reduce the odour and associated complaints, there has been limited success with aeration and chemical treatments. Due to the expected growth of residential units to the south of the pumping station, it is anticipated that the amount of odour complaints would increase.

4. **Operational challenges.**

Operational challenges related to the treatment and disposal of septage and leachate at the facility are mainly related to:

- *Treatment operation and maintenance:* The strength of raw septage in comparison to raw domestic sewage is one of the biggest challenges to face during treatment. Indeed, septage contains significant levels of grease, scum, grit, rocks, rags, plastics, and other debris. The high solids content causes significant ragging and subsequent downtime of pump and treatment equipment while the high concentrations of nutrients may cause corrosion in the pipes and processing equipment. Cleaning and maintaining process equipment is fundamental. However, the existing receiving station does not have means to remove rocks, large debris and rags which cause problems with operation of the grinder and clog the sewage pump impellers. Periodically, the grinder unit is removed from the wet well and shipped to the manufacturer for replacement of its grinding parts. Removing and reinstalling the grinder is time consuming and costly.

Pump impellers have been replaced frequently. Both pumps need to be taken out of service on a regular basis for maintenance.

- *Inability to balance flow into the system:* The bulk delivery of leachate in large truck load quantities at the facility does not allow for good mixing and dilution of the waste. Furthermore, in the past years, both the Town's wastewater treatments plants have been negatively impacted to the delivery of leachate in truck load quantities to the point of threatening the Town's ability to maintain compliance with the Plants' Environmental Compliance Approvals. As leachate from "young" wastes is characterized by high chemical oxygen demand (COD) and biological oxygen demand (BOD) values (and by high ratios of BOD to COD), low pH and initially high in metals, the delivery of leachate in truck load quantities creates a situation where the Plant's biology is impacted due to the shock loading of high strength wastewater.

2.6.3 Potential Solutions

As the existing facility is facing the aforementioned challenges, alternative solutions to overcome current problems must be considered. Options that should be considered include:

1. Mixing and balancing flow to minimize spikes.
2. Enclosed off-loading area.
3. Ventilation/odour control to minimize off-site impacts.

As the existing Craigleith Main Lift Station is located proximate to both current and future residential properties and near to the Highway 26 which does not provide a safe access to the facility, this location does not present the conditions to overcome current challenges. Therefore, the option to relocate the existing septage receiving station from the Craigleith Main Lift Station to a new location should be considered.

The summary memorandum in **Appendix F** provides additional detail on the Septage Receiving Station.

3 Process Upgrades

The following section reviews the odour related issues identified at the SLS as well as presents the process upgrades based on the information developed in the Technical Memorandum.

3.1 Odour Control

It is understood that there are odour complaints received by the Town from residents, it is also understood that the existing sodium hypochlorite odor control system is not operational. The pumping station not only receives sewage from the general collection system but also septage from the adjacent rural areas and leachate from the landfill. It is noted in the leachate record that load are received in batches of as much as five (5) loads a day on weekdays, however, the loading is inconsistent as there are periods of low loading. The septage and holding tank waste is also quite random but more consistent than the leachate loading record. We expect that 99% of the odour complaints at the site are associated with the off-loading and mixing of these high strength wastes with the collection system sewage.

The arrangement of the off-load piping is located up-stream of the channel grinder **Error! Reference source not found.**, the piping is terminated above the channel sewage level. The piping arrangement permits the entrainment of air with the discharge stream, which likely flows full and causes an abundance of turbulence during the discharge. This action results in exacerbating the development of air space contaminants associated with the production of hydrogen sulfide and mercaptans.

Figure 3-1: Photo of the Septage and Leachate Discharge Pipe

In an effort to reduce the air entrainment and odour production, the drop pipe should be extended below the sewage surface by about 75 – 100 mm below the average water level. The distance between the pipe discharge and the channel bottom should be a minimum of 200 mm to ensure there is no accumulation of rags and debris; however, the entrance velocity of the septage should clear most of the material out of the discharge zone. It is understood that the receiving station for septage and leachate is likely to move to the Craigleith Sewage Treatment Plant which is ideal. This move will be the single most effective method of mitigating the odour concerns at the SLS as well as the most energy and cost effective, given also the residential development planned for the property located south of the SLS. If the receiving station remains at the SLS, we suggest odour monitoring equipment be installed to assess whether the odour related issues are directly related to the receiving station.

On-site odour mitigation technologies would consist of the following:

- Biofilter
- Activated Carbon
- Photoionization (UV)
- Ozone

The advantages and disadvantages of the various odour control technologies are presented in Table 3-1.

Table 3-1: Odour Control Technologies

Odour Control Technology	Advantages	Disadvantages
Biofilters	• Effective for the reduction of odour emissions • Simple Operation (i.e., exhaust fan and water supply) • Effective in cold temperatures	• Requires a large footprint • Significant amount of water required to maintain moisture in media • Performance affected by short-circuiting, pH depression and high temperatures • Requires media replacement (10-year basis)
Activated Carbon	• Effective for the reduction of odours compounds • Small footprint • Simple to operate • Engineered media can be used to target specific compounds	• More frequent media replacement than biofilter • Potential future disposal issues due to the flammability of the media.
Photoionization (UV)	• Effective for the reduction of odour compounds • Small footprint • Treatment is not impacted by temperature or relative humidity • Handles spikes in compounds	• New to North America (widely used in Europe) • Higher energy used than adsorption technologies
Ozone	• Effective for the reduction of odour compounds • Larger footprint • Treatment is not impacted by temperature or relative humidity • Handles spikes in compounds	• New to North America (widely used in Europe) • Higher energy used than adsorption technologies

At this time, we are not recommending further evaluation of odour control measures until such time as the destination of the Receiving Station has been selected. Once the new location will be selected, design options for an odour control system should be considered.

3.2 Process Upgrades

As a result of the process and electrical evaluations, the following are the process upgrades recommended for the SLS to achieve a more energy efficient pumping operation and at the same time reduce pump clogging and the need for the inlet channel grinder. Generally, the modifications for the process would include the following:

- Replace the existing centrifugal pumps with pumps that operate efficiently in the main duty range of the facility, pumps shall be a self cleaning semi-open impeller designed for wastewater pumping
- Replace the suction header to allow the new pumping arrangement to drawing from either Wet Well with any of the pumps in operation
- Replace the two (2) 200 mm diameter forcemain transition piping sections
- Provide actuated valves at the entrance of each 300 mm forcemain as well as on the drains for each forcemain

- Remove the inlet channel grinder
- In the short-term, extending the discharge pipe of the Septage/Leachate below the inlet channel water surface with reduce the air entrainment and turbulence which will help mitigate some of the odour generation

The pump selection and analysis are based on the current conditions and observations of the anticipated flow range currently observed at the facility. The final design criteria should be assessed once the final capture area of the Craigleith SLS is determined. Currently, the anticipated flow and total dynamic head range is identified in Figure 3-2. The pump selection identified (Xylem NZ 3202 HT) is a 45 HP pump which, in comparison to the existing 100 HP pumps, achieves much of the same flow range but with a peak overall efficiency of about 68% at an operating point of 80 L/s @ 25 m TDH.

The selection of the most efficient pump for the most frequent operating condition 30 L/s @ 13.5 m TDH does not lead itself well to the increase in flow and head required for all system capacities. We would recommend selecting 2 sizes of pumps: one covering the lower range of flows 20 – 100 L/s, and one covering the range of 100 L/s to the ultimate flow projected for the facility. One potential arrangement is to provide a lead/lag pumps to cover the lower flow range (which could be achieved with the pump provided) and a second pair of pumps to cover the higher flow range. Figure 3-3 presents numerous pump options for the higher flow range up to 265 L/s @ 58 m TDH. The main contributor to the relatively steep system curve is the 2,200 m forcemains, their length creates the significant pressure requirement at higher flow rates even though the velocities at within the recommended ranges (0.8 – 2.5 m/s).

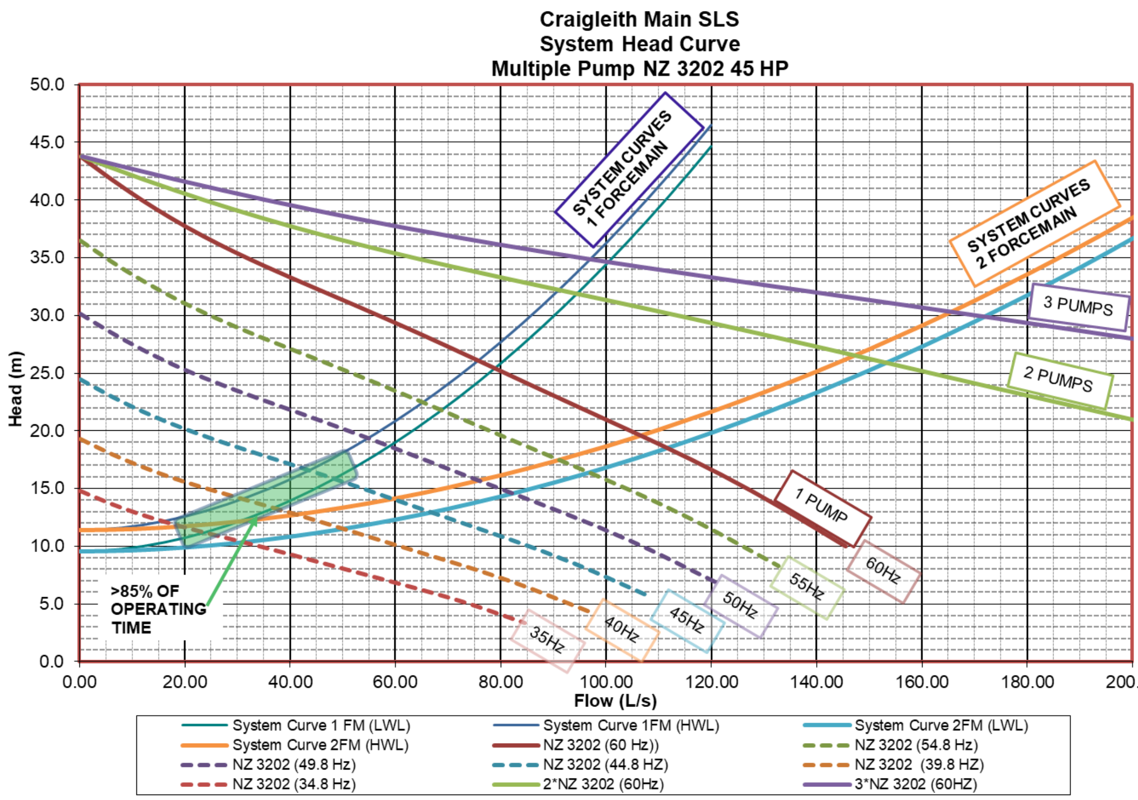


Figure 3-2: System Head Curves and Potential Pump Selection

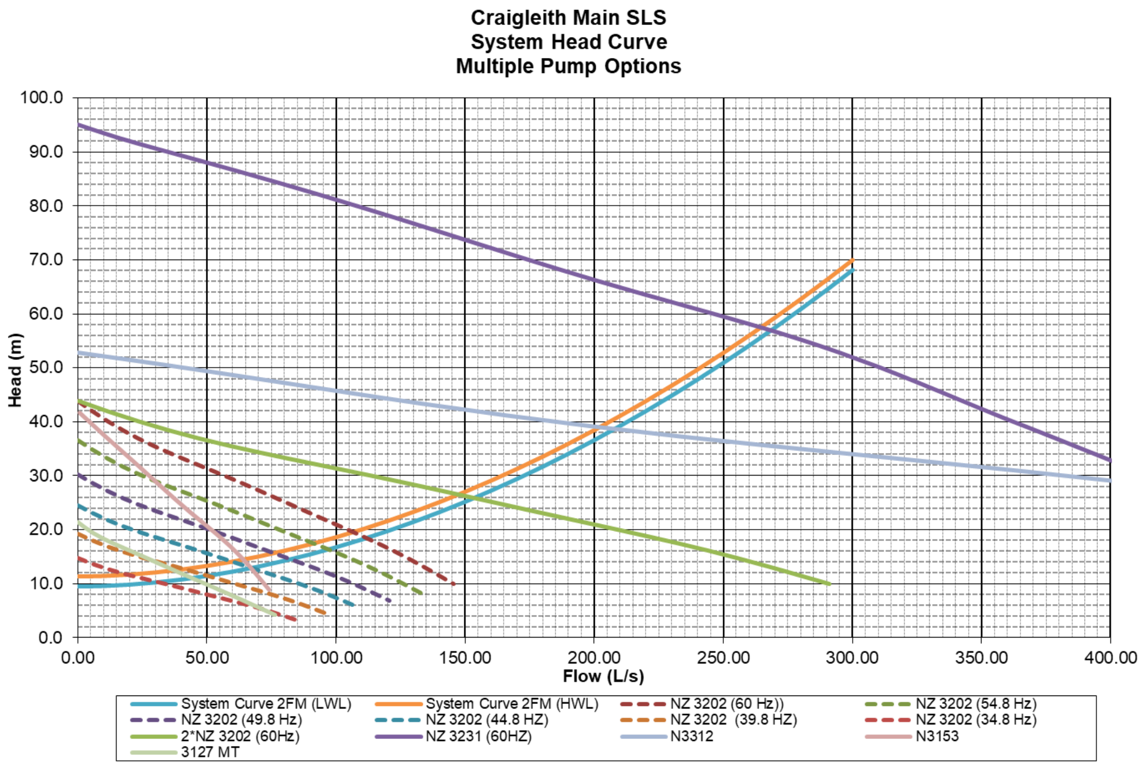


Figure 3-3: Pump Selection Options for High Flow Profiles

4 Conclusions

- Building Classification and Ventilation
    - The Wet Well is a Class 1 Division 1 Group D area requiring twelve (12) air changes per hour for infrequent occupancy. The air changes are to be provided by an exhaust fan rather than the existing supply fans.
    - The operations area (Dry Well and the main operating floor) is an unclassified area provided a minimum of six (6) continuous air changes per hour. The two spaces are considered one continuous air space as there is no physical separation between these spaces. If less than six (6) air changes per hour is provided, the electrical rating changes to Class 1 Division 2 Group D.
    - To meeting the NFPA requirements under the current arrangement, the outdoor air should be discharged into the dry well space and the exhaust louvre open continuously to ensure fresh air is provided and circulated through the entire area. This air would require heating which would represent a major source of waste energy.
- Process Evaluation
    - The existing 100 HP pumps are sized for a peak efficiency design point of 120 L/s @ 36 m TDH, the facility currently operates with the following flow characteristics:
        - The pumps operate above 20 L/s 97.4% of the time
        - The pumps operate above 50 L/s 12.1% of the time.
        - The pumps operate between 20-50 L/s 85.3% of the time.
        - The pumps operate at their rated capacity (120L/s) < 0.3% of the time.
    - The existing pumps are operating outside of the preferred operating region about 90% of the time which leads to recirculation and seal failure.

    - The pumping operation is the single largest energy consumer of the facility, operating at an average wire-to-water efficiency of about 40%. Efficient pumping operations achieve average wire-to-water efficiencies in the range of 60-70%.
    - The energy evaluation indicates that pump P2 operates more efficiently the sewage pump P1.
- Energy Audit
    - The energy audit indicates that the sewage pumping operation represents 63% of the energy consumed at the Craigleith SLS. The building ventilation, heating and basic building loads represent the remaining distribution of power consumed in the facility.
    - Significant energy savings may be achieved through upgrading the sewage pumping operations which the selection of pumps that achieve a minimum of 60% efficient under the average flow conditions. Upgrading the building ventilation and associated heating requirements will achieve improvements in energy consumption with an overall expectation that a 40% energy efficiency is achievable for the facility.
    - Energy offset and recovery operations with the greatest opportunity of meeting the overall energy conservation goals are adding Photovoltaic Cells to the southern roof of the building and providing some heat recovery system on the HVAC units depending on the final design of the building ventilation systems.
    - There are numerous Energy Efficiency Funding opportunities through the Green Municipal Fund, Retrofit Programs, IESO and the GICB infrastructure program.
- Electrical Upgrades
    - Much of the existing electrical equipment is original to the station (c. 1985) and nearing its expected design life. With planned upgrades to the pumping arrangement and ventilation systems, it is recommended that all the existing distribution equipment be replaced rather than modified to suit the new systems.
    - A new outdoor diesel generator should be sized to provide emergency power to the entire SLS and shall include a sound attenuation enclosure suitable for the area and automatic controls coupled with a new Auto Transfer Switch.
    - The service entrance breaker is rated for 600Amps but is set to trip at 300Amps which aligns with the capacity of the 300kVA transformer, as such, the service entrance has sufficient capacity to support the future upgrades and the transformer sized for the new pumping arrangement.
- PLC Upgrades
    - The general arrangement of the existing pumping station instrumentation and process control narrative is consistent with the current industry standards.
- Odour Control
    - The existing odour control system is no longer functional and numerous odour complaints have been received by the Town.
    - Septage and Leachate are received at the facility in significant amounts which are likely the largest source of odours at the facility.
    - Photoionization would be the most applicable technology for odour control at the SLS; however, it will also result in the highest energy demand of all technologies.
- Septage and Leachate Receiving Station
    - The existing septage and leachate receiving station is located in an area where access and egress to the site and to adjacent areas can be complex and potentially a safety hazard.

   - The existing receiving station does not remove large debris and rocks which increases the risk of ragging or pump damage and subsequent downtime of pump and treatment equipment, increasing maintenance and operational costs of the equipment.
   - The bulk delivery of leachate in large truck load quantities at the facility does not allow for good mixing and dilution of the waste which increases odour issues.
- Facility Site
   - If the septage and leachate receiving station is relocated to the Craigleith Wastewater Treatment Facility, then the pumping station side could be reworked to improve security and reduce off-site impacts without significant restrictions. This should be coordinated with the upgrades to the facility necessary to increase/improve the overall facility optimization.

5 Recommendations

- Building Arrangement
   - Separation of the Dry Well from the ground floor operations and electrical equipment space is the most efficient method of reducing the heating energy efficiency while achieving the area classification for the electrical distribution equipment.
   - Construction of an air lock to isolate the below grade Dry Well from the above grade operations floor which will de-classify the operations area, then address the classified area with the following:
      - Provide Class 1 Division 2 Group D equipment (process and electrical) in the Dry Well space only.
      - Provide gas detection including alarming and intermittent ventilation based on occupancy for the Dry Well.
      - The above grade operations and electrical area would be provided with heating and ventilation to achieve the area heating and cooling loads only.
   - The estimated cost of this work is $340,350 (+/- 25%) including engineering and contingency.
- Process
   - Short-term pumping efficiency improvements can be achieved by simply placing pump P2 as the duty pump.
   - Development of the design criteria and future SLS capacity is required to define the ultimate pumping capacity of the facility.
   - Replace the existing centrifugal pumps with pumps that operate efficiently in the main duty range of the facility, pumps shall be a self-cleaning semi-open impeller designed for wastewater pumping
   - Replace the suction header to allow the new pumping arrangement to drawing from either Wet Well with any of the pumps in operation
   - Replace the two (2) 200 mm diameter forcemain transition piping sections
   - Provide actuated valves at the entrance of each 300 mm forcemain as well as on the drains for each forcemain
   - Remove the inlet channel grinder
   - In the short-term, extending the discharge pipe of the Septage/Leachate below the inlet channel water surface with reduce the air entrainment and turbulence which will help mitigate some of the odour generation

  - We recommend replacing the existing 100HP pumps with 2 sets of sewage pumps, one set would be designed to optimize the pumping efficiency in the range of 20 – 60 L/s and the second set would optimize the pumping efficiency in the range of 100 – 200 L/s.
  - The estimated cost of the proposed upgrades is $2.8M +/-25% including engineering and contingency. This value will be dependant on the ultimate pumping capacity of the facility, as the larger pumps required to meet the peak pumping demand are in the range of $200,000 per pump for the supply only.
- Electrical and Energy Conservation
  - It is recommended that as part of the facility upgrades the electrical distribution equipment and pump control Variable Frequency Drives be replaced which will improve the efficiency of the wire-to-water efficiency of the station.
  - It is recommended that this MCC lineup and it's associated housekeeping pad be removed as part of the electrical upgrades. This will provide greater working space for the control panel and electrical equipment located behind the MCC as well as free up space for a proposed air-lock structure around the stairway entering the dry well. By locating the new generator outside of the building, there will be sufficient wall space available to relocate the service entrance point elsewhere.
  - Updating the onsite SCADA interface and programmable logic controller should be undertaken as part of the electrical upgrades. Consider replacing the float switches with the Multitrode level control as a more reliable switch.
  - The estimated cost of the capital upgrades associated with this work is $1.38M (+/-25%) including Engineering and Contingency.
  - The estimated annual energy savings over the current baseline is a reduction of approximately 45% (81,692 vs 150,012 kWh consumed). With the installation of the PV Solar Panels to offset the energy consumption, the estimated annual production rate is about 14,500 kWh with would result in a total energy balance of greater than 50% reduction below the 2021 consumption rates.
- Odour Control
  - In the short-term, the Septage/Leachate discharge pipe should be extended below the water level in the entrance channel to the SLS. The estimated cost of this upgrade is $12,500 +/-25% including engineering and contingency.
  - Depending on the final location of the Septage/Leachate Receiving Station, the odour control requirements of the SLS should be revisited at that time.
  - Odour monitoring is recommended as the first step in determining the causation and magnitude of treatment required for the site; as such, we recommend installation of a monitoring device in the short-term to track odour related compound concentration ranges and trending to determine if these are a result of the current Septage/Leachate receiving operation.
  - At this time, we would defer any cost estimates regarding odour control as the preferred alternative is to relocate the septage receiving station which should address the majority of the odour concerns.
- Facility Site
  - A visual tree barrier between the facility and the trail would allow to reduce the visual impact of the facility with the Georgian Trail and the future land development area to the south. The estimated cost of the fencing and tree barrier would be approximately $75,000 +/- 25%.

- As the existing roadway is deteriorating, the asphalt needs to be rehabilitated. The estimated cost of rehabilitating the asphalt would be in the order of $75,000 - $125,000 +/- 25% depending on whether any of the base material could be reused.

6 References

- Craigleith Area – Duplicate Forcemain and Sewage Pump Station Modification Record Drawings issued by Ainley and Associates Ltd., December 2006
- Township of Collingwood – Contract 8 – Sewage Pumping Station, Ainley and Associates Ltd. As Constructed Drawings, August 1984
- Hauled Waste Amounts – 2019 to 2021
- Hauled Landfill Leachate Amounts – 2019 to 2021
- Craigleith SLS Genset Information
- Craigleith SLS Amended Certificate of Approval – August 25, 2005
- TBM Energy Conservation and Demand Management Plan – 2019
- Craigleith SLS Hydro Consumption 2019 – 2021
- Craigleith SLS Septage & Leachate Receiving Station Engineering Assessment Report – CC Tatham, September 2014
- Craigleith SLS Equipment Data
- Collection System Model and As-Built Drawings
- Monitoring Data – Collected by EVB Engineering

7 CLOSURE

WT Infrastructure Solutions appreciates the opportunity to work on this project and we look forward to the opportunity to review this report with the facility and their operational team.

We trust this meets with your approval. If you have any questions or comments, please contact the undersigned.

Regards,

WT INFRASTRUCTURE SOLUTIONS INC.

LICENSED PROFESSIONAL ENGINEER
J. A. WITHERSPOON

Jamie Witherspoon, P.Eng.
President
Project Manager

APPENDIX A

TM #1: Building Area Classification and
Ventilation Review

TECHNICAL MEMORANDUM

PROJECT: **Craigleith Main Sewage Lift Station**
DATE: October 20, 2021
TO: **Brent Rolfus, PM Town of the Blue Mountains**
FROM: Jamie Witherspoon, WT Infrastructure
RE: **Area Classification and Building Ventilation Review**

This technical memorandum is provided as an overview of the electrical area classifications for the Wet and Dry Well areas of the Craigleith Main Sewage Lift Station (SLS).

1.1 Electrical Area Rating

The following table provides a summary of the classification and other related information for the rated areas at the SLS, as dictated by the National Fire Protection Association (NFPA) 820, *Standards for Fire Protection in Wastewater Treatment and Collection Facilities 2020 Edition.* Refer to the attached Drawing E.1.1 for a visual representation of the classification extents.

Table 1: Current Electrical Classification of Process Areas

Process Area	Code Reference	Ventilation	NEC Area Classification (All Class 1, Group D)	Materials of Construction	Fire Protection Measures
Wet Well including Venting[1]	Table 4.2.2 (Row 14/32)	NNV	Division 1	NC	CGD[3]
Dry Well	Table 4.2.2 (Row 15a/b)	C D	Unclassified Division 2	NC	FE

Notes:
1. Extent of Class 1 Div.1 area is within 0.9m radius of the vent and Class 1 Div. 2 within 1.5m radius of the vent and 0.9m of the access hatches.
2. All area classifications apply to the entire enclosed room.
3. Required if mechanically ventilated or opens into a building interior. Currently this is not the case as the mechanical ventilation is not continuous.

<u>Legend</u>

Item		Item	
A	No ventilation or ventilated at less than 12 air changes per hour.	**LFS**	Low flame spread index material
B	Continuously ventilated at 12 air changes per hour.	**CGD**	Combustible gas detection
C	Continuously ventilated at 6 air changes per hour.	**FAS**	Fire alarm system
D	No ventilation or ventilated at less than six air changes per hour.	**FE**	Portable fire extinguisher
NC	Non-combustible material	**FSS**	Fire suppression system
NNV	Not Normally Ventilated		

Dry Well Review

As identified in the NFPA, the below grade area of the Dry Well is unclassified provided the space has a ventilation rate of 6 continuous air changes per hour or greater. The below grade building volume is approximately:

- Depth below grade = 181.00 m (FFE) – 0.3 m (floor thk.) – 171.00 m (basement slab FFE) = 9.7 m
- Dimensions of Dry Well = 6.4 m x 7.7 m
- Below Grade Dry Well Volume = 478 m^3
- Ventilation Rate to Achieve 6 air changes per hour = 478 m^3 x 6 ÷ 3600 s = 0.8 m^3/s.

The pumping station area above grade is classified the same as the lower area due to the fact that there is no solid physical separation between the two spaces. Furthermore, if a door or wall was constructed between the two (i.e. top of stairs or mid-way), the rating of the above ground floor would still be the same as the lower area unless an airlock was constructed, see per Figure 1 below.

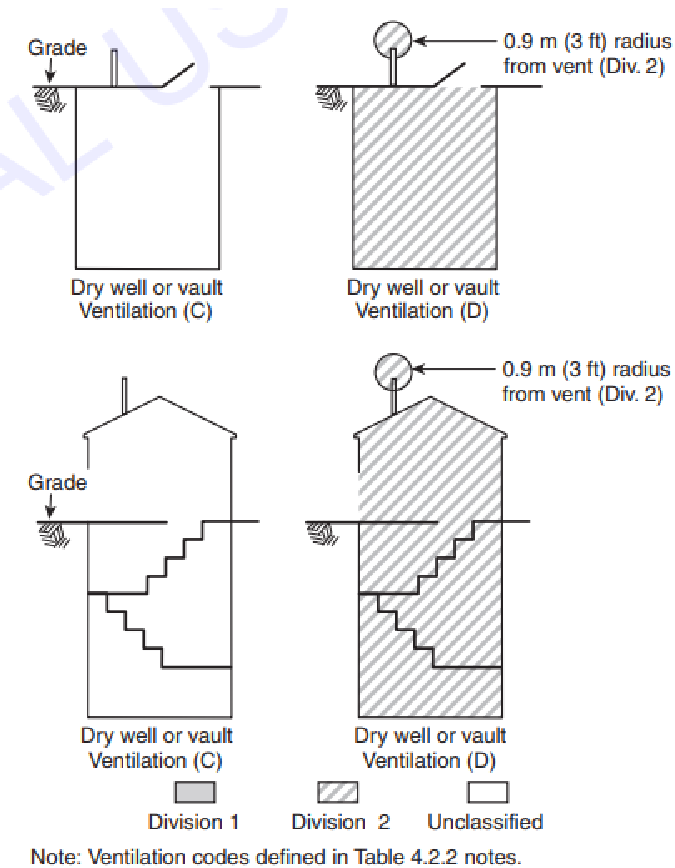


Figure 1: Dry Well Classification

The existing supply fan (FN-1, see attached Photo 1), provides a ventilation rate of approximately:

- Fan properties: 1800 RPM, 750 mm diameter, 150 mm pitch, 4 blade steel fan
- Flow rate = πr^2 x rpm x pitch = π x $(0.75/2)^2$ x 1800 x 0.15m ~120 m^3/min @ 1800 rpm
- Approximate Current Ventilation Rate = 2 m^3/s.

The current FN-1 capacity is sufficient to achieve the minimum required air exchanges to modify the rating of the Dry Well environment (Class 1 Div 2 to Unclassified), provided that the unit was/is operated continuously. However, based on the facility layout and original controls design there are a few issues that lead to recirculation of internal air which have the potential to result in the accumulation of gases, increasing the room temperature and ultimately not actually remove the internal air.

Currently there is only one exhaust air damper servicing the Dry Well and operations floor area, which is the damper associated with the Generator air inlet and is typically closed at temperatures less than 25°C.

Wet Well Review

It is our understanding that the Wet Well ventilation fans are for the infrequent occupancy of the wetwell space (i.e. to clear the “sewer gases” for inspection and maintenance). For occupancy it is recommended that 12 air changes per hour are provided to a Class 1 Division 1 space and the air space oxygen and hydrogen sulfide gas composition is tested and cleared prior to entering the confined space.

The approximately volume of the wet well:

- Depth Wet Well Chamber = 9.7 m
- Dimensions of Dry Well = 4.85 m x 7.7 m
- Below Grade Dry Well Volume = 362 m^3 (less the benching)
- Ventilation Rate to Achieve 12 air changes per hour = 362 m^3 x 12 ÷ 3600 s = 1.2 m^3/s.

The existing supply fans (FN-2 &3) each provide a design rated capacity of 1,100 L/s at 38 mm water column. As such, with a two-fan operation the ventilation rate is approximately double the required rate.

1.2 Upgrade and Design Considerations

Dry Well and Operations Area

Ventilation upgrades to the Dry Well area should be considered as part of the planned sewage lift station upgrades. The Dry Well electrical area classification dictates the above grade operations area classification due to the fact that there is no physical separation between these two areas. Physical separation is defined as no permanent openings, gas tight separation between the two spaces (access points or louvres). In order to create the physical separation, the NFPA would require exterior access or an Airlock; which in this case would require two doors and an intervening vestibule type area that is pressurized (NFPA -820 9.4). This may not be realistic given the space available within the main floor area or stair well. In order to evaluate the most effective/efficient design the following options should be reviewed:

1. All electrical equipment rated to Class 1 Division 2 Group D, with ventilation and monitoring to address health and safety of the air space and building climate controls.
2. Providing continuous outside supply air at 6 air changes per hour, including necessary air heating, serviced by a supply and exhaust fan (this should be discussed further as the code does provide leeway for “not routinely entered spaces”).
3. Construction of an air lock to isolate the below grade Dry Well from the above grade operations floor which will de-classify the operations area, then address the classified area with the following options
    a. De-classify the Dry Well area as per 2 above;
    b. Provide Class 1 Division 2 Group D equipment in the Dry Well space only;
    c. Provide gas detection including alarming and intermittent ventilation based on occupancy with item 3b.

Wet Well Area

The below grade Wet Well space and above grade alcove areas are Class 1 Division 1 rated areas. The Supply fans servicing the wet well draw outdoor air from the alcove space discharging “fresh” air 200 mm above the maintenance platform within the wetwell. The NFPA code requires exhaust fans (not supply) for process facilities no routinely entered by personnel otherwise both supply and exhaust fans are required.

Further to the existing arrangement is the location of the fresh air inlets, once the access hatches to the wet well are opened the exhaust from the space will discharge through the two hatches which is the area that the supply fans are drawing air from, essentially recirculating the air space of the Wet Well.

As part of the planned upgrades, the piping for the fresh air inlet should be terminated in an alternate location not influenced by the Wet Well air space or exhaust air space.

Odour control options will be reviewed under separate cover.

Respectfully Submitted

Jamie Baker, P.Eng.
Sr. Municipal Engineer

APPENDIX B

TM #2: Process Mechanical Review

PROJECT: **Craigleith Main Sewage Lift Station**
DATE: November 5, 2021
TO: **Brent Rolufs, PM Town of the Blue Mountains**
FROM: Jamie Witherspoon, WT Infrastructure
RE: **Process Review –Equipment and Operations**

This technical memorandum is provided as an analysis of the current process equipment and operating conditions of the Craigleith Main Sewage Lift Station (SLS). This will include the main process equipment (pumps, channels, gates, piping and valves) as well as the instrumentation and controls.

1.1 Process Equipment Summary

The following table provides a summary of the process equipment servicing the SLS.

Table 1: Process Equipment

Process Area/Equipment	Make/Model	Design Condition	Operating Conditions (L/s)	Materials of Construction	Comments
Dry Well					
Sewage Pumps	Arora 612 A 6"x8"x18"	120 L/s @ 36 m TDH, 1150 RPM	30 - 180	Cast Iron Casing	100HP 575/3/60
Process Piping	2006 - SS 316 10S A778 Douglas Barwick Fabrication 1984 – SS 304 Douglas Fabrication, reinforced 200 mm				
Isolation Valves	2006 - AVR/Resilient Seated Gate Valve/Non-rising stem/Epoxy Coated/FF Flange (300/200) 1985 – Resilient Seated Gate Valves (200)				
Discharge Check Valves	2006 – Valmatic Surgebuster Swing Check Valve Model: 208/018 (200), 250 psi rated				
Wet Well[1]					
Inlet Sewer	750 mm Ø Concrete (D100) @ 0.55% Slope; Full Pipe Capacity: 825 L/s				
Inlet Channel	1200 mm (W) x 1200 mm (D) x 5000 mm (L); Critical Depth @ 825 L/s: 382 mm				
Manual Bar Screen	10 mm x 50 mm Alum. Flat Bar, 50 mm bar spacing c/w reinforcements and drip tray @ 30°				
Channel Grinder	Muffin Monster Channel Grinder				
Channel & Wall Gates	3 Gates: 750 mm x 750 mm (rising/non-rising stem/embedded frame: TBD)				
Pump Inlets	2 Pump Section Inlets per wet well; Each inlet 350 mm c/s bell end, 275 mm off floor, wet well benching W-E with no benching between inlets				

Note 1: Wet well components were not visually inspected, the summary is based on the original design drawings.

1.1.1 Pump Properties

The Arora centrifugal sewage pumps installed at the SLS have the following properties:

- 8” inlet, 6” outlet, 18” maximum impeller diameter.
- Actual impeller: 446 mm
- Rated Capacity: 120 L/s @ 36.34 m TDH
- Rated Speed: 1150 rpm @ 60 Hz
- Maximum Efficiency at Rated Capacity: 77.51% (mechanical)
- Flow at the Best Efficiency Point: 144.6 L/s
- Minimum Continuous Stable Flow (MCSF): 44.15 L/s

1.1.2 Current Piping/Pumping Operating Conditions

Suction Piping

The suction piping consists of two piping arrangements depending on the pump being operated, as such they are reviewed separately below.

Pump No. 1 (North)

Pump No. 1 drawings raw sewage from wet well #1 (north) via an isolated 350 mm suction direct to the pump 200 mm inlet. The is a 350 mm full bonnet, resilient seated gate valve at the pipe penetration from the wet well. Pump No. 1 can only draw sewage from the north wet well.

Pump No. 2 (South)

Pump No. 2 drawings raw sewage from wet well #1 & 2 via an isolated 350 mm suction from each well through a fabricated Wye connection direct to the pump 200 mm inlet. The is a 350 mm full bonnet, resilient seated gate valve at each pipe penetration from the wet well. Pump No. 1 can draw sewage from both the north and south wet wells.

Each of the pump suctions located within the wetwell consist of a bell end 350 mm Ø 90 ° bend inlet. The base of the bell is located (as designed) with 275 mm clearance from the floor of the wet well.

Discharge Piping

The discharge piping from each individual pump consists of a 150 mm discharge, expanding to 200 mm including isolation and check valves on each discharge. The 200 mm piping discharge to a common 300 mm header, through a magnetic flow meter, which then is split through a fabricated Wye fitting, reducing to 200 mm into each of the 2,200 m existing forcemains. A full bonnet isolation gate valve is provided to isolate each of the force mains. Each of the forcemains increases from the 200 mm connection points inside the station to 300 mm via a 200→300 mm reducing fitting outside of the station, underground.

Each of the force mains includes a 200 mm drain piping, isolation gate valves and discharge through a combined outlet into the north wet well. Outside of the station, located on each of the force mains are 300 mm isolated by-pass connections which enable isolate of the pumping station and direct connections with each forcemain.

The two 300 mm Ø forcemains can operate in parallel or in isolation, at the time of review both force mains were operating in parallel.

1.1.3 Pump Control Narrative

Under normal operation and flow conditions, the pumps operate in a lead-lag arrangement where only one of the sewage pumps is operating concurrently (lead pump). The pumps will alternate between lead/lag pump on a 2-1 duty cycle where pump P1 will operate as the lead pump for 48hours before switching over the lead pump duties to pump P2 which will then operate as the lead pump for 24hours and so on.

The pump speed/flow is automatically controlled by the PLC within the SLS control panel. A proportional control loop is programmed which will increase the pump speed as the level in the wet well rises to a maximum speed setpoint (95%) and reduce the pump speed as the level in the wet well falls to a minimum speed setpoint (34%). With this arrangement, the pump flow will generally match the inlet flow into the SLS. The inlet flows into the SLS typically stay at or above the minimum pump flow and so the lead pump operates on a continuous basis. If the lead pump is unable to keep up with the flow through the SLS the level within the wet well will rise until it hits a "lag_pump_start" setpoint. At which point, the lag pump will start up to assist in lowering the level within the wet well. If the level within the wet well reaches the high-level float, then both pumps will run at 100% speed.

1.1.4 System Hydraulics

The SLS is currently controlled based on the set points identified in the attached Figure 1: Wet Well Level Set Points; additionally, the static lift of the station is based on the forcemain discharge elevation at the Craigleith Wastewater Treatment Plant (WWTP) as per the CC Tatham & Associates Ltd., Pre-tender Issuance Jan. 2000, Drawing HP2. These elevations dictate the static lift of the hydraulic system and are summarized below.

- Discharge Elevation at the Craigleith WWTP: 185.55 m (Liquid Level at Headworks Inlet).
- SLS High Water Level: 174.00 m (Transducer Max Level)

- SLS Low Water Level: 172.2 m (LWL Shut-off)

Additionally, the analysis is based on the materials arrangements and installed details provided I the following drawings:

- Ainley and Associates Ltd. Sewage Pumping Station (Contract 8), Pre-Tender Drawings dated March 1985.
- Ainley Group, Craigleith Area – Duplicate Forcemain and Sewage Pump Station Modifications Record Drawings dated April 2006.

The pipe hydraulic properties are based on published information for the specific equipment; and finally, the analysis has been developed based on the following operation conditions.

Operating Condition 1 - Single Pump Operation through a Single Force main
Operating Condition 2 – Single Pump Operation through Parallel Force mains
Operation Condition 3 – Dual Pump Operation through Single Force main
Operation Condition 4 – Parallel Pump Operation through Parallel Force mains

Each of these conditions is assessed below.

Operating Condition 1

Under Operation Condition 1, the single pump operating condition ranges from approximately < 30 L/s @ 10.5 m TDH (30 Hz) to about 112 L/s @ 36.5 m TDH (60 Hz) which is considered the normal operation condition and range of the pump (Figure 1). The velocities in the system are listed in the following Table 2.

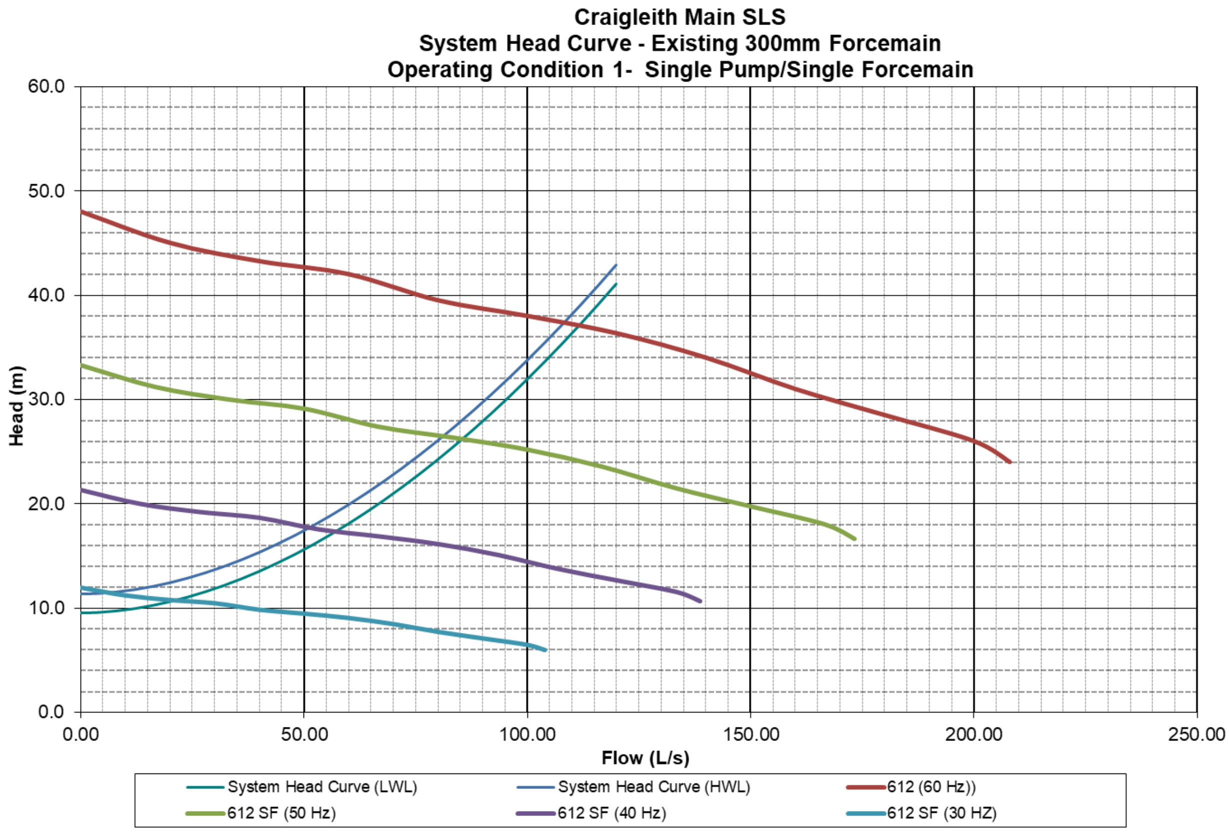


Figure 1: Condition 1 System and Pump Curve Evaluation

Table 2: Operating Condition 1 Pipe Velocities

Forcemain Sections	Pipe Velocity (m/s) at Indication Flow	
	30 L/s	120 L/s
350 mm Suction	0.32	1.28
200 mm Suction/Discharge	0.85	3.4
300 mm Forcemain	0.39	1.54

Under the low flow condition, the pipe velocity in the forcemain does not provide sufficient energy to maintain entrained solids in suspension. The recommended forcemain piping velocity is 0.8 to 2.5 m/s (MOE 1985).

Operating Condition 2

Under Operation Condition 2, the single pump operating range is increased due to the lower friction headloss in the main force main section between the lift station and the sewage plant. The operating conditions range from approximately < 30 L/s @ 10.5 m TDH (30 Hz) to 165 L/s @ 30.5 m TDH (60 Hz) which is considered the normal operation condition and range of the pump (Figure 2). The velocities in the system are as per the following Table 3.

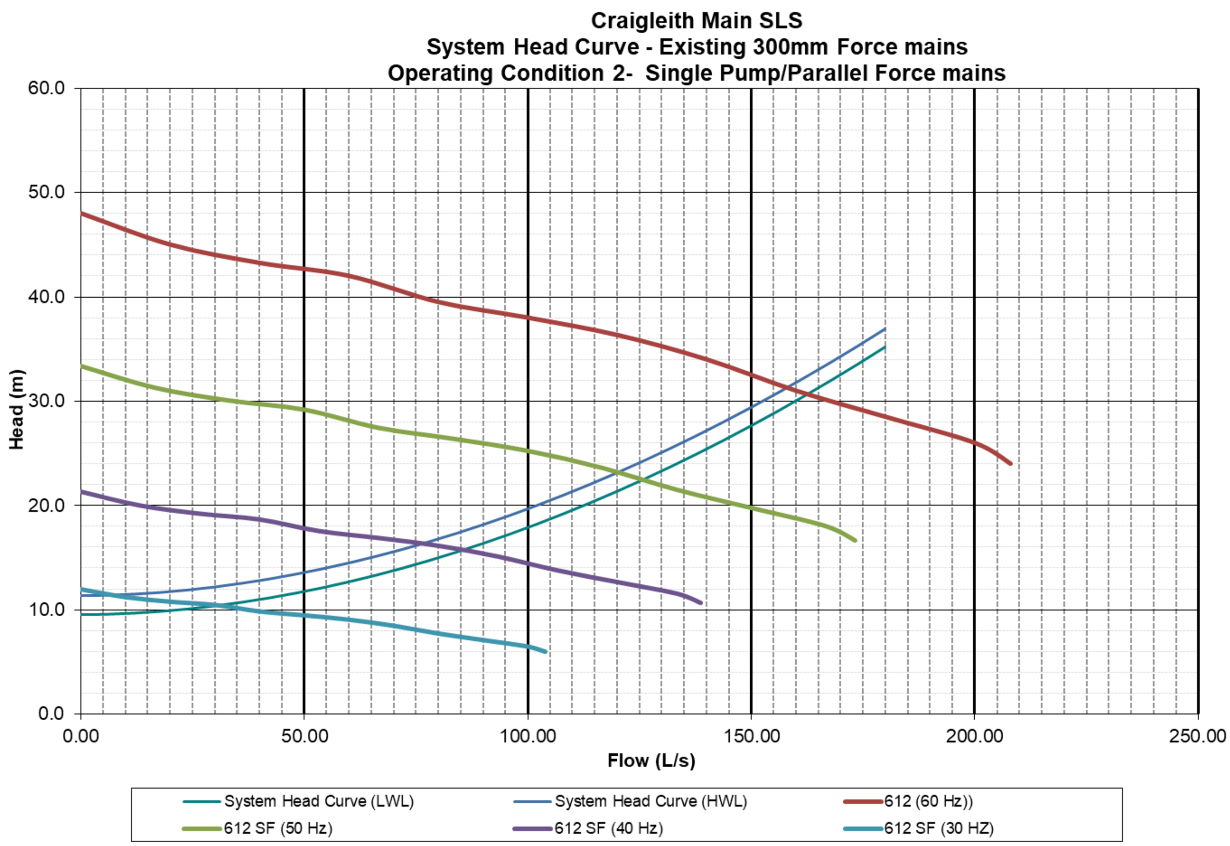


Figure 2: Condition 2 System and Pump Curve Evaluation

Table 3: Operating Condition 2 Pipe Velocities

Forcemain Sections	Pipe Velocity (m/s) at Indication Flow	
	30 L/s	165 L/s
350 mm Suction	0.32	1.8
200 mm Suction/Discharge	0.85	4.7
300 mm Discharge Header	0.39	2.1
200 mm Forcemain	0.43	2.4
300 mm Forcemains	0.19	0.4

Operating Condition 3

Under Operation Condition 3, the duty pump and the lag pump are operating in parallel discharging through a single forcemain. The main bottleneck in this arrangement is the single forcemain, which greatly reduces the flow capacity of the system. As indicated in the attached figure, the increase in flow between a single pump operating at 60 Hz (~112 L/s @ 36.5 m TDH) and the two pumps operating in parallel at 60 Hz (~125 L/s @ 42 m TDH) is about a 13 L/s increase in total discharge flow rate.

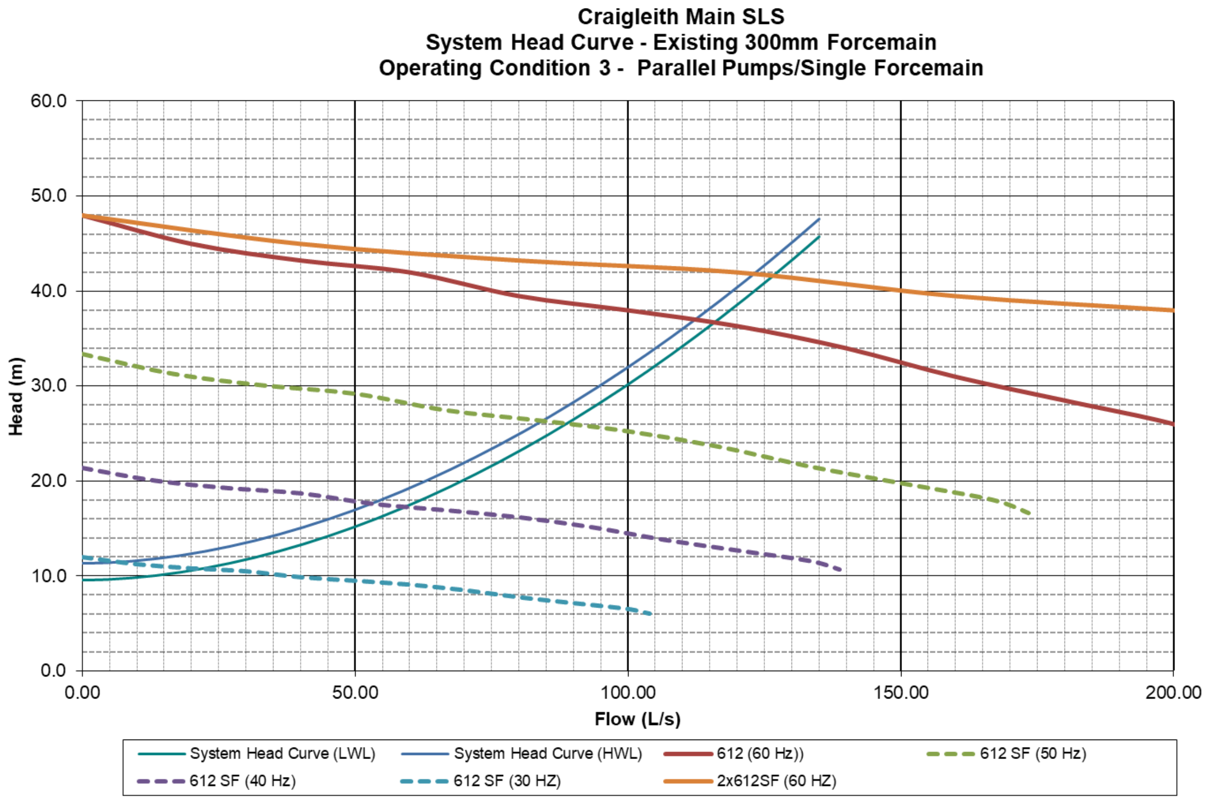


Figure 3: Condition 3 System and Pump Curve Evaluation

Operating Condition 4

Under Operation Condition 4, the duty pump and the lag pump are operating in parallel discharging through parallel forcemains. This scenario identifies the maximum capacity of the existing system based on the control elevations noted above. The maximum system capacity, both pumps operating at 60 Hz is approximately 218 L/s @ 38.5 m TDH, the maximum flow is impacted directly by the water levels in both the SLS and the WWTP so there is some variability (+/- 5%) in this maximum value depending on the friction factors of the forcemain segments and the operating water levels.

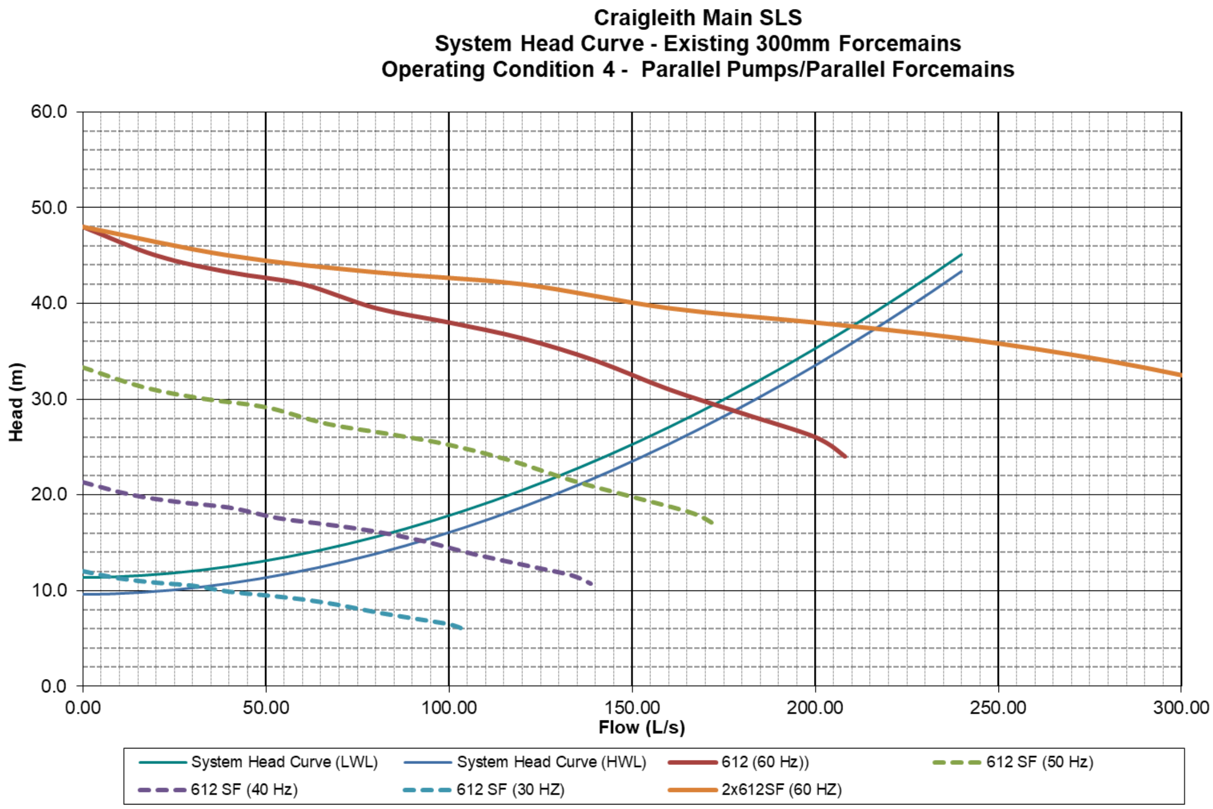


Figure 4: Condition 4 System and Pump Curve Evaluation

The system velocities are provided in the following Table 4 for the various piping segments in the system.

Table 4: Operating Condition 4 Pipe Velocities

Forcemain Sections	Pipe Velocity (m/s) at Indicated Flow
	218 L/s
350 mm Suction	1.16
200 mm Suction/Discharge	3.1
300 mm Discharge Header	2.8
200 mm Forcemain	3.1
300 mm Forcemain	1.6

1.2 Operating Monitoring Data

1.2.1 System Flows

The system monitoring data includes the discrete level data available from the Ultrasonic level measuring units and the discrete flow metering data available from the magnetic flow meter. The data was made available by the system integrator ARO for the period of April 2020 to current (Flow) and June 2021 to current (level). A trending plot of the bulk data from both instruments is provided in Figure 5.

The data indicates that the system operates predominately at flow rates less than 50 L/s, with a 90th percentile less than 100 L/s. There are also some extreme events in the data record that include flows up to 250 L/s; however, upon further evaluation of these events it is apparent that the operating levels in the wet well are greater than the range of the ultrasonic units. As indicated in Figure 5, the peaks in the wet well level are recording a measurement of 3000 mm which is the range of the ultrasonic unit. As reported by operations during the last event, there were collection system surcharging taking place which is the only way in which the 100 HP pump could achieve flow rates greater than about 218 L/s (i.e., the static head condition was reduced). In addition, there were reports of multiple pump failures during this time which also led to surcharging of the influent sewer, thereby reducing the static lift condition of the pump operation.

We expect that provided there are no pumping failures, the true instantaneous peaks of the SLS is approximately 150 L/s. The most frequent flow rate recorded during the monitoring period of April 2020 to September 2021 was 35 L/s; 150 L/s represents a peaking factor of 4.3 which is a reasonable factor, using 250 L/s represent a peaking factor of 7.1 which would indicate a significant I&I problem. It should be noted here that further analysis of the Craigleith WTP instantaneous flow record would be a useful comparison to the SLS record in development of the final design criteria for pump selection.

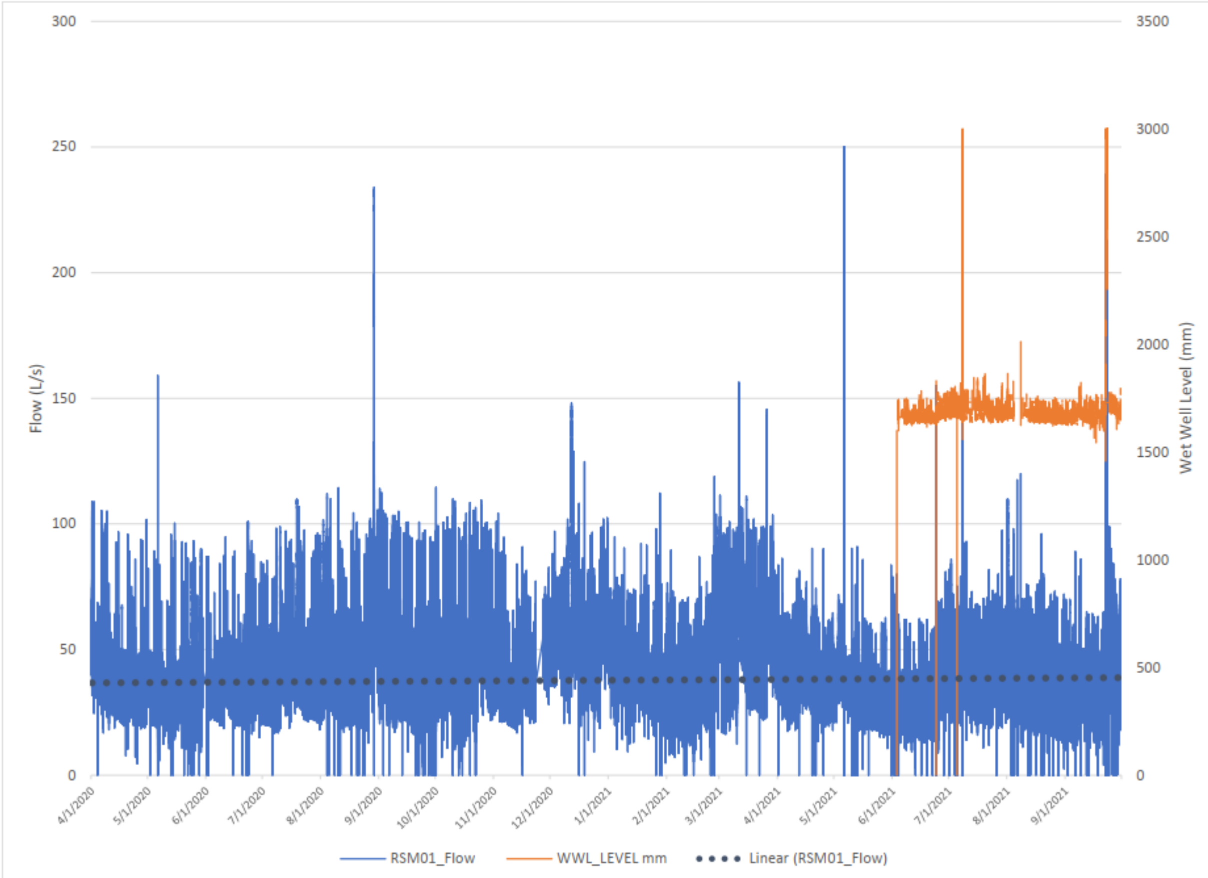


Figure 5: Flow and Level Trending (April 2020 – September 2021)

1.2.2 Flow and Duration Frequency

The following load duration curve depicts how frequently the pumps are operating at or above a specified flow rate (L/s). This data represents flow data captured from the SCADA historian covering a period ranging from April 2020 to November 2021.

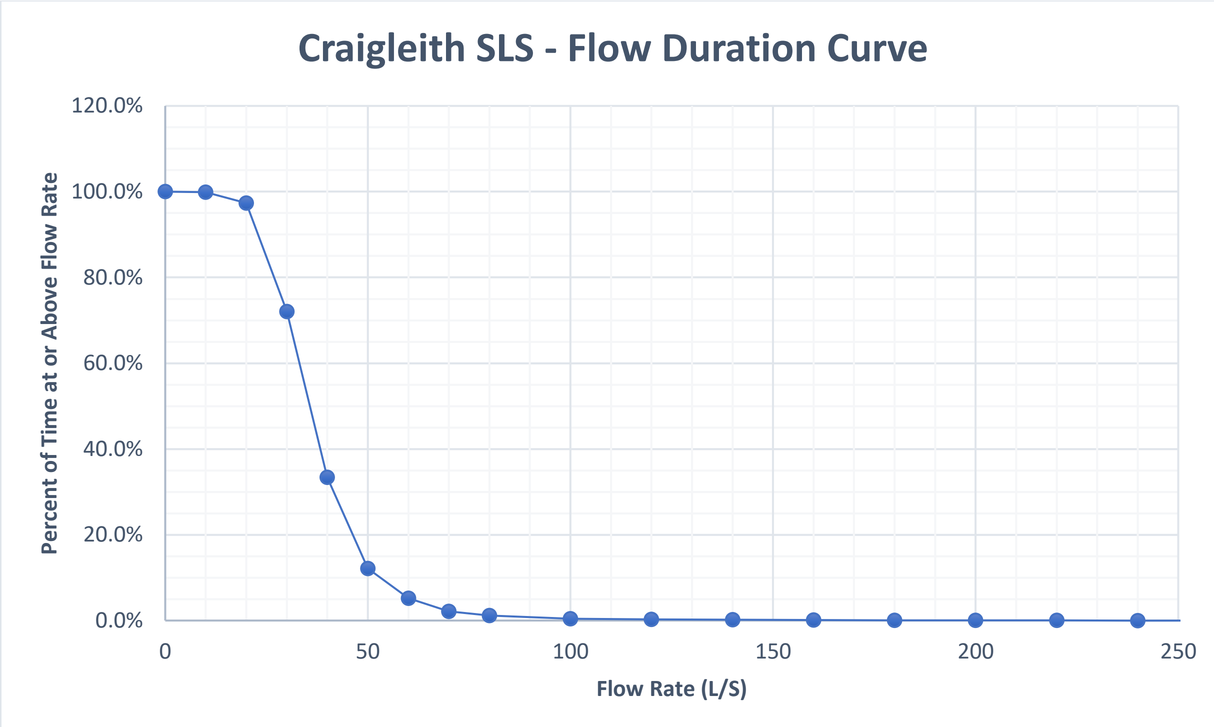


Figure 6 - Load Duration Curve

From this curve, we can make the following statements.

- The pumps operate above 20 L/s 97.4% of the time
- The pumps operate above 50 L/s 12.1% of the time.
- The pumps operate between 20-50 L/s 85.3% of the time.
- The pumps operate at their rated capacity (120L/s) < 0.3% of the time. The historical flow data didn't indicate how many pumps were in operation at each flow rate however based on some data sampling. It would be expected that flows more than 100L/s would represent both pumps in operation and so the pumps would not be operating near their individual rated capacities at 120L/s.

This analysis is cause for concern since the pumps are not operating anywhere near the best efficiency point. Supplying the pumps through a VFD does allow the pump efficiency to be maintained over a wider range of flows however the pumps appear to be operating at the lower limits of there operating range. VFD and motor efficiency will also start to drop off under very lightly loaded conditions. To evaluate this, the system efficiency was calculated.

1.2.3 System Efficiency (Wire-to-Water)

The Wire-to-Water (WTW) efficiency of the sewage pumping system relates to how effectively the system converts electrical power into hydraulic power. Essentially, a system with a higher wire-to-water efficiency will require less electrical energy (kWh) to pump the same volume of fluid.

The WTW efficiency is simply the pump efficiency multiplied by the motor efficiency and the variable frequency drive (VFD) efficiency at the pump operating point. It can be calculated as the hydraulic power output of the pump divided by the electrical power at the input of the VFD. An efficient pumping station should see WTW efficiencies of 60-70%.

To determine the Wire-to-Water efficiency of the Craigleith SLS, electrical energy loggers were installed on the input to each pump (VFD) to measure the electrical energy consumed by each pump over a 30-day period (Oct. 14, 2021 – Nov. 13, 2021). The energy data was aligned with system flow data recorded in the SCADA historian over the same period. Hydraulic system pressures were approximated based on the calculated system curves. The WTW efficiency will vary with flow (L/s) and pump arrangement.

The WTW efficiency was calculated and plotted on Figure 7 for each of the following operating conditions.

- Condition 1 – Pump P1 in Operation
- Condition 2 – Pump P2 in Operation
- Condition 3 – Both Pumps in Operation

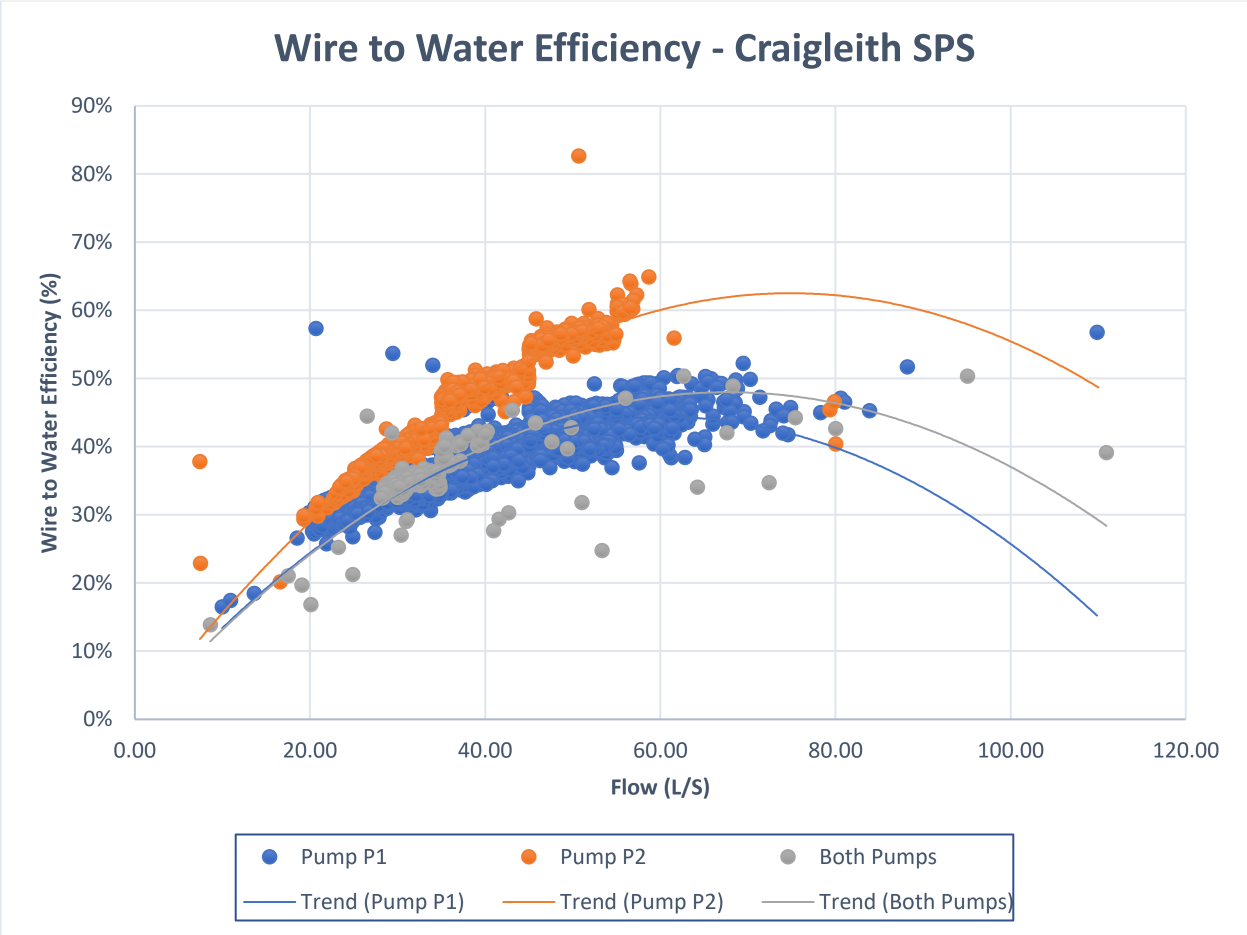


Figure 7 - Wire to Water Efficiency

As indicated in the load duration curve (Figure 6), the pumps very rarely operate above 60L/S and so there are insufficient data points available to properly predict the best efficiency point and where that efficiency begins to drop off at higher flow rates. The trend lines are provided for visual aid only and don't necessarily reflect the best efficiency point pump performance at flow rates beyond 60L/s. From this curve, we can make the following statements.

- The best efficiency point for the system occurs beyond 60L/s. The efficiency drops off significantly below 60L/s.
- The WTW efficiency of the system generally ranges between 20-65% with an average calculated WTW efficiency of 40%.
- Sewage pump P2 operates more efficiently the sewage pump P1.
- Sewage pump P2 provides are more predictable and consistent output for a given electrical input.
- Both pumps operate at system flows below 80L/s at a very low WTW efficiency.
- There is considerable room for improved efficiency and energy conservation.

As expected, we can see that the pumps are operating well below their best efficiency point. The pump, VFD and motor efficiency all begin to suffer under lightly loaded conditions which makes for a very inefficient pumping arrangement. It is interesting to note that the pump P2 performs more efficiently than pump P1. It was noted that the VFD supplying P2 had been replaced with a modern PWM AC drive. Pump P1 is still being supplied by it's original VFD (1985 vintage). Improvements in VFD technology are likely showing up as improved efficiency and greater control over P2.

Interim efficiency gains could be had by simply reversing the duty cycle so that P2 operates more frequently than P1 until further pump upgrades are performed.

Respectfully Submitted

Brad MacColluch, P.Eng.
Electrical Engineer

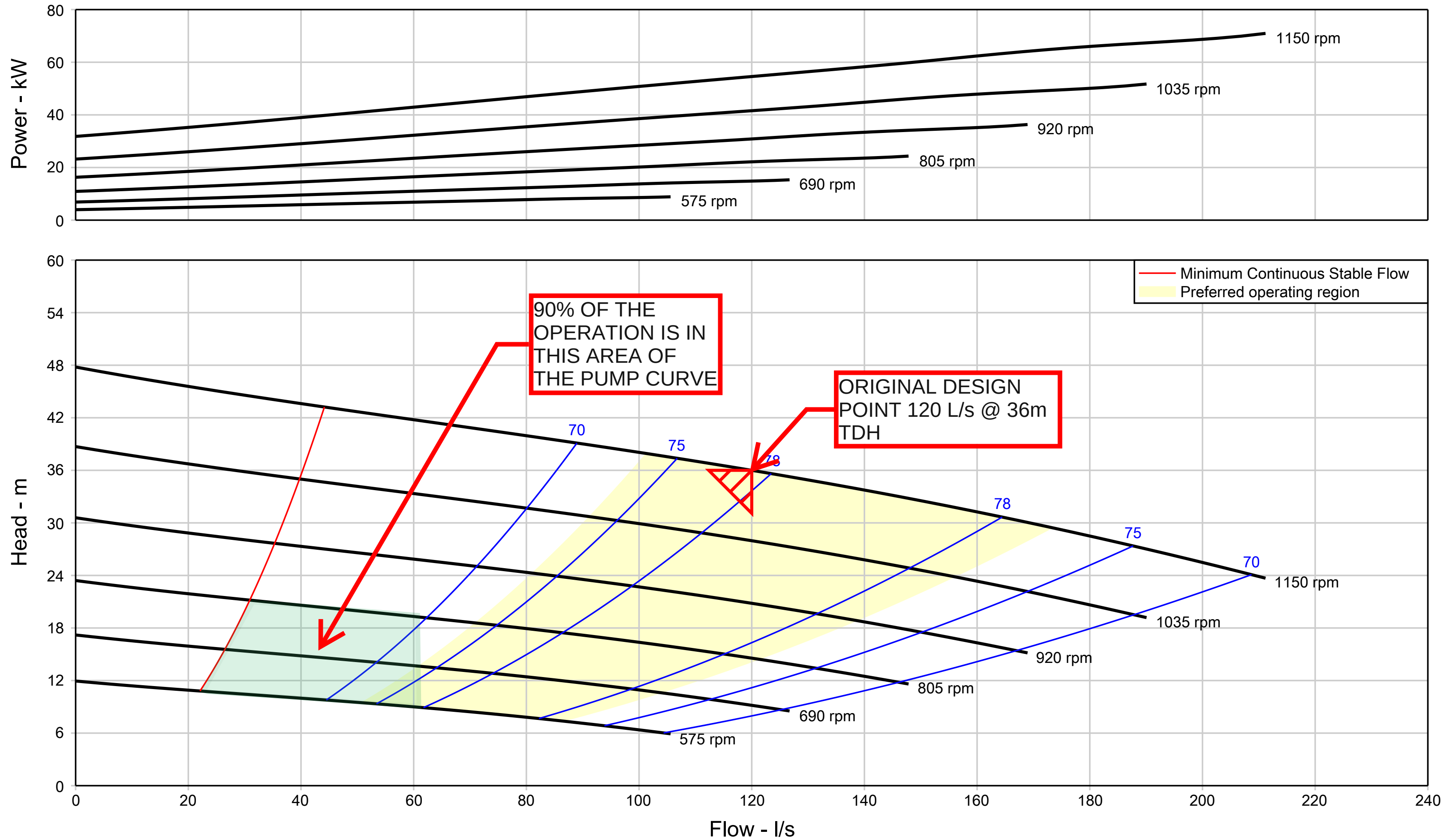
Jamie Baker, P.Eng.
Sr. Process Engineer

PENTAIR

Customer :
Project name : Default

Multi-Speed Performance Curve

Encompass 2.0 - 21.4.0



Item number	: 001	Size	: 610 - 6x8x18	Flow, rated	: 120.0 l/s
Service	:	Stages	: 1	Differential head / pressure, rated	: 36.00 m
Quantity	: 1	Efficiency	: 77.51 %	Speed, rated	: 1150 rpm
Quote number	: 233066	Power, rated	: 54.57 kW	Impeller diameter, rated	: 446 mm
Based on curve number	: 16-6x8x18-1150	NPSH required	: 4.31 m	Fluid density, rated / max	: 0.998 / 0.998 kg/dm3
Date last saved	: 03 Nov 2021 9:32 AM	Site Supply Frequency	: 60 Hz	Viscosity	: 1.00 cSt
		Nominal speed	: 1180 rpm	Cq/Ch/Ce/Cn [ANSI/HI 9.6.7-2010]	: 1.00 / 1.00 / 1.00 / 1.00

CRAIGLEITH MAIN SEWAGE LIFT STATION

Figure 1: Wet Well Level Setpoints

Depthabove Wetwell Base Slab (m)	Geodetic Elevations (m ASL)	Depth (%)	Control Description
6.00 m	177		Collection System By-Pass Flap Gate (Elevation TBC, Ainley Drawing 81042/43-SW2)
4.00 m	175.00		Top of Walkway in Wetwell
3.50 m	174.50		Transducer (Underside of Operating Floor)
3.10 m	174.10		Inlet Sewer Invert (750 ø)
			High level Alarm (North/South)
3.09	174.09		Lag Pump Max Speed
3.00 m	174.00	100%	Transducer Span/High Level Alarm (North/South)
2.81	173.81	70%	Lag Pump Start (per data sheet in control cabinet)
2.80 m	173.80		Influent Channel Invert
			Invert of Inlet Channel Isolation Gates
			Lead Pump Max Speed
2.70 m	173.70	67%	Lag Pump Stop (per data sheet in control cabinet)
2.50 m	173.50	63%	Lead Pump Start (per data sheet in control cabinet)
2.00 m	173.00	50%	Lead Pump Stop (per data sheet in control cabinet)
2.00 m	173.00	50%	Lag Pump Start per control screen
1.85 m	172.85		Lag Pump Stop per control screen
1.60 m	172.6	40%	Lead Pump Start per control screen
1.45 m	172.45	36%	Lead Pump Stop per control screen
1.40 m	172.40	35%	Pump Impeller
1.25 m	172.25	31%	Low Level Alarm (North)
1.20 m	172.2	30%	Low Level Alarm (South)
0.81	171.81	20%	Pump Suction Piping Centreline
0.28	171.28	7%	Pump Suction Inlet
0.10	171.10	2%	Invert of Partition Wall Isolation Gate (G-003)
0.00 m	171.00	0%	Tank Floor

APPENDIX C

TM #3: Energy Audit & Renewables Review

TECHNICAL MEMORANDUM

PROJECT: **Craigleith Main Sewage Lift Station**
DATE: November 30, 2021
TO: **Brent Rolufs, PM Town of the Blue Mountains**
FROM: Jamie Witherspoon, WT Infrastructure
RE: **Electrical Energy Audit and Conservation Measures**

This technical memorandum is provided as an analysis of the current electrical energy consumption of the Craigleith Main Sewage Lift Station (SLS). This will include a review of historical energy consumption to establish an electricity baseline for the current operating conditions. Opportunities for energy conservation and energy offset is provided. Recommendations will made for incorporation in the proposed upgrades to the SLS.

1 Electricity Baseline

Based on historical utility metering, the Craigleith SLS consumes approximately 150,000 kWh of electricity on an annual basis. Figure 1 - Electrical Energy Consumed by Load Group below provides a breakdown of the annual kWh consumption by the various loads within the SLS. These values were approximated by installing electrical energy loggers on the sewage pumps over a 4-week period. This metering data was used to estimate the historical kWh consumption from the pumps based on historical flow data captured from the SCADA system. The energy consumed by the ventilation system and basic building loads was estimated based on nameplate data and an assumed 24/7 operation. The remaining kWh were attributed to the building heating system. This model covered the 12-month period ranging from September 2020 to August 2021. Actual percentages may vary year over year depending on variations between flows through the SLS and heating demands but this figure provides insight into the relative contribution of each load group.

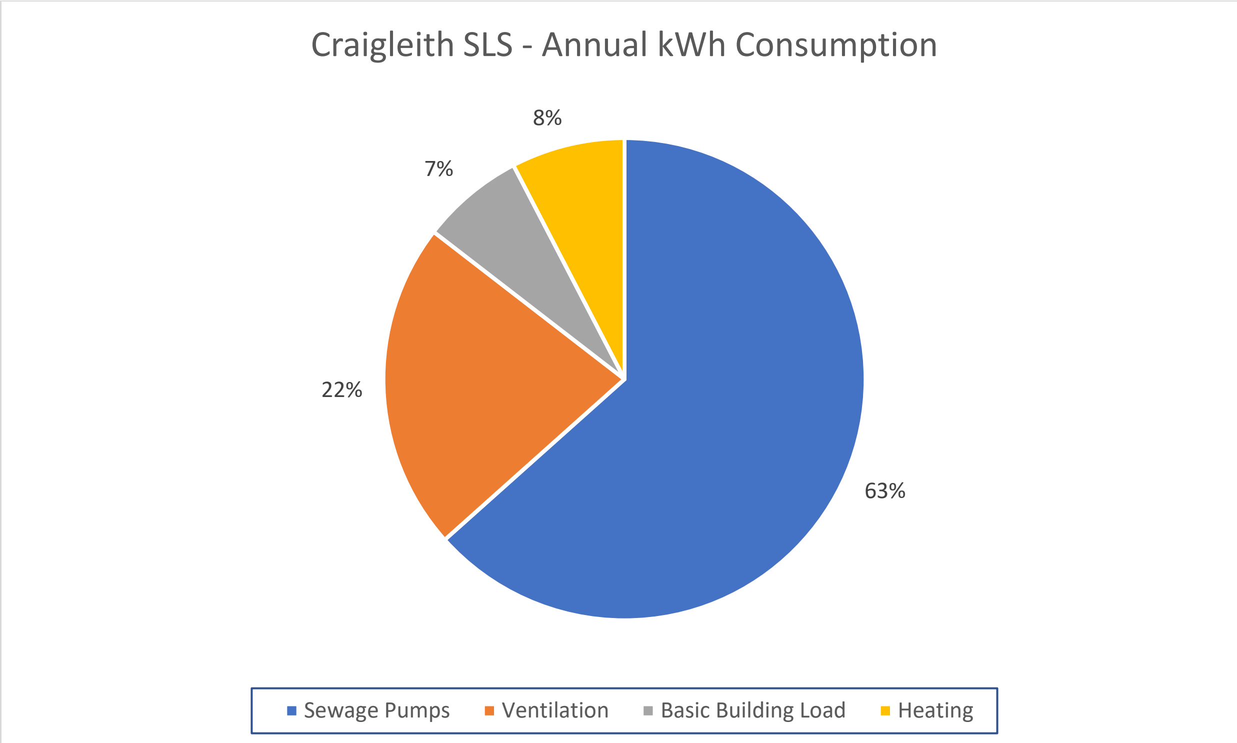


Figure 1 - Electrical Energy Consumed by Load Group

1.1 Sewage Pumps

The sewage pumps represent the largest contributor to electrical consumption within the SLS. The energy consumed by the sewage pumps is directly related to the volume of fluid passing through the pumping station. The annual kWh consumed by the sewage pumps was calculated by measuring their kWh consumption over a 30-day test period (Oct 14 – Nov 13, 2021). Comparing this data to system flow data stored in the SCADA historian over the same period allowed for the historical prediction of the kWh consumption based on historical flow data. From this analysis, the calculated annual kWh consumption from the sewage pumps was:

- Sewage Pumps Annual kWh = **95,097 kWh / year (63%)**

1.2 Building Ventilation

To mitigate the hazards associated with the potential accumulation of hazardous gases, the Craigleith SLS is provided with a continuous building ventilation system. The ventilation system consists of three (3) supply fans bringing fresh air into the building namely FN-1, FN-2 & FN-3.

FN-1 provides continuous fresh air into the Drywell area and interconnected operations area to modify the area classification for this space from a Class 1, Div.2 to unclassified. This fan must run continuously to prevent the accumulation of gases within the dry well and connected operations area. Without this fan, all electrical equipment within the dry well and operations area would need to be rated for a Class 1, Div. 2 environment.

FN-2 & FN-3 provide fresh air into the wet well but only operate for infrequent occupancy of the wet well space.

For the purposes of the energy analysis, only FN-1 was considered in operation. It is, by far the largest contributor to the energy consumed by the building ventilation system. To estimate the historical energy consumed by the building ventilation system, an electrical meter was used to measure the electrical demand while in operation. This spot check was then extrapolated over a 12month period assuming a 24/7 operation:

- Meter Reading: 4.7Amps @ 580V = 4.72kVA
- Calculated Demand: 4.72kVA @ 0.8PF = 3.78kW
- Calculated Annual Energy: 3.78kW x 365days * 24hours = **33,113 kWh / year (22%)**

1.3 Basic Building Loads

The basic building loads include the 120V loads supplied by lighting panel LP-A. To determine the annual kWh consumption for these loads, amp readings were taken for each circuit to determine their electrical demand. Not all loads operate continuously, and so daily run times were approximated for each load to determine their daily kWh consumption as summarized below.

- Indoor Lighting: 3.9 kWh / day
- Outdoor Lighting: 2.5 kWh / day
- Generator Heater/Battery: 12.5kWh / day
- Instrumentation, Control and Comm.: 7kWh / day
- Other: 2.5kWh / day
- Total: 28.4kWh / day
- Calculated Annual Energy: 28.4kWh / day * 365 days = **10,366 kWh / year (7%)**

1.4 Heating Loads

The Craigleith SLS is heated by four (4) electric element forced air space heaters. There are three-unit heaters (UH1, UH2, UH3) installed in the operations area and controlled by a thermostat within that space. The fourth unit heater is installed in the dry well to provide heating to that space.

The annual energy consumed by the electric heaters was calculated as the remainder of the total annual kWh (as billed by Hydro One) less the sum of the kWh consumed by the sewage pumps, ventilation, and basic building loads:

- Heating (kWh) = **11,436 kWh / year (8%)**

2 Opportunities for Energy Conservation

The following opportunities should be considered as part of the planned sewage lift station upgrades to improve the overall efficiency of the site, conserve energy and reduce the overall “carbon footprint” of the site. With the implementation of these design changes, it can reasonably be expected to reduce the overall energy consumed by the facility by 40% or more. The Table 1 summarizes where these efficiency gains can be made.

Table 1: Potential Energy Savings

Load Group	Current Electricity Baseline	Potential Savings (%)	Estimated Future Baseline
Sewage Pumps	95,097 kWh	33%	62,764 kWh
Ventilation System	33,113 kWh	>90%	3,311 kWh
Basic Building Loads	10,366 kWh	<1%	9,899 kWh
Heating System	11,436 kWh	50%	5,718 kWh
Total	**150,012 kWh**		**81,692 kWh**

2.1 Sewage Pumping System

As discussed in a separate technical memo “Process Review – Equipment and Operations”, the existing sewage pumping system is very inefficient with an average wire-to-water efficiency of 40%. An efficient pumping system should see efficiencies in excess of 60%. Like for like replacement of the pumps is not recommended. The new pumps should be selected so that their best efficiency point occurs between 30-50 L/s under normal system operating conditions.

Increasing the system efficiency to 60% would result in a 33% reduction in energy consumed by the sewage pumps and **21%** reduction in overall electrical energy consumed by the SLS.

2.2 Ventilation System

As discussed in a previous technical memorandum “Area Classification and Building Ventilation Review”, the construction of an airlock was proposed to separate the dry well from the operation area of the building. This was proposed based on concerns with the effectiveness of the existing ventilation system however this would prove to be an effective means of reducing the overall ventilation requirements for the building as well.

By providing a physical separation between the dry well and operations area, continuous ventilation of the dry well would not be required which would virtually eliminate the existing ventilation demands for the building. The dry well could be provided with intermittent ventilation based on occupancy only. The electrical equipment within the drywell would be replaced with equipment rated to Class 1 Division 2 Group D.

For the purposes of this analysis, it is conservatively assumed that this would result in a minimum 90% reduction in energy consumed by the ventilation systems which corresponds to a **20%** reduction in overall electrical energy consumed by the SLS on annual basis.

2.3 Basic Building Loads

The only real opportunity for energy conservation with the basic building loads would be through a lighting retrofit. The existing lighting primarily consists of fluorescent tube fixtures. Modern LED fixtures could provide a 20% reduction in energy consumption compared to fluorescent fixtures or an estimated 467 kWh savings per year. The increased reliability and reduced maintenance costs for the LED fixtures would provide the greatest benefit.

2.4 Heating Loads

In keeping with the municipalities objective to reduce overall greenhouse gas emissions, it is recommended the electric heating be maintained within the SLS building. Efficiency gains can be made by installing an air source heat pump to satisfy the bulk of the heating demands within the building. These heat pumps use a refrigeration cycle to capture heat from within the outside air and pump it indoors.

The heating demand can also be reduced by separating the dry well from the operations area with an air lock system. As noted previously, this will eliminate the need to provide continuous fresh air into the building for ventilation purposes. During the heating season, this continuous supply of cold outside air leads to increased heat loss and an increased demand on the heating system.

A detailed heat loss model is required to quantify the potential gains of these upgrades however engineering judgment would expect heating loads to be reduced by 50% or more with the proposed upgrades. This would result in a **4%** reduction in annual energy consumption.

3 Energy Offset Opportunities

The single sloped, South facing roof of the Craigleith SLS lends itself as an ideal location for a rooftop photovoltaic (PV) solar array. The existing roof provides approximately 120m^2 of surface are for installation of PV modules however, accounting for existing roof and building vent penetrations and allowing a 1m working space around the perimeter of the array, it can conservatively be expected to provide a minimum of 60m^2 of PV coverage. Modern PV modules provide efficiency of 20% or more. 60m^2 of PV modules would provide up to 12kW of electrical power. This array would match nicely with a 10kW inverter. Typically, PV array capacity is 20-

30% larger than the inverter rating knowing that the PV output will not be operating at full capacity throughout the year.

The proposed arrangement was modeled using the RETScreen software produced by NRCan. This software includes local weather data which can be utilized to model and predict annual energy production (kWh) from the proposed solar array based on geographical location, system arrangement and orientation. The proposed system was modeled as a fixed mount system mounted with a tilt angle of 15º (existing roof pitch) and an azimuth angle of -15º. With this model, it was calculated that the proposed array would produce 14,583 kWh of energy an annual basis.

This array would be connected as a grid-tie system in which it operates in parallel with the utility supplied connection. Under normal operating conditions, the electrical demand of the SLS would exceed the capacity of the proposed solar array and the array output would be supplemented by the utility supply. Under rare occasions, the solar array may feed energy back into the utilities distribution system. The province offers a NET metering program for this purpose which would allow renewable energy producers to receive credit for power supplied to the utility grid. This credit would be applied to future utility bills. An application would be required to establish the NET metering connection with Hydro One. This should be included with the PV design.

4 Energy Efficiency Funding Opportunities

This project has the capacity to contribute to Town objectives for the Energy Conservation and Management Plan through system optimization and energy efficiency. There are several potential funding opportunities for energy efficiency measures that could be considered, including funds promoted by the Federation of Canadian Municipalities or utility-managed electricity programs. Furthermore, the possibility of third-party financing for energy retrofits can be considered. Identified opportunities are listed below:

- **Green Municipal Fund:** The Federation of Canadian Municipalities established the Green Municipal Fund in 2000 to drive local green innovation across the country.
  - **Capital Project: GHG Impact Retrofit.** Combined grant and low interest loan (Up to 25% as a grant and the remainder as a loan) for up to 80% of eligible costs for a maximum of $5 million per project**.** This grant support projects aimed to reduce GHG emissions by at least 30% compared to the current or baseline performance of the building. Baseline performance may be estimated where the retrofit changes the size or function of the building. Eligible projects may focus on a single building or a portfolio of buildings. If the project focuses on a portfolio of buildings, each building must meet the 30% reduction target. Up to one-third of the total GHG reductions achieved compared to the building's current or baseline performance can come from renewable energy generated onsite.
  - **Capital Project: GHG Reduction Pathway Retrofit.** Combined grant and low interest loan (Up to 25% as a grant and the remainder as a loan) for up to 80% of

eligible costs for a maximum of $5 million per project**.** This grant supports projects in implementing one or more phases of a GHG reduction pathway as defined in a GHG reduction pathway feasibility study or equivalent. The project must aim to reduce GHG emissions by at least 50% compared to the current or baseline performance of the building within 10 years and by at least 80% compared to the current or baseline performance of the building (i.e., near net-zero GHG emissions) within 20 years. Studies may focus on a single building or a portfolio of buildings. If the study focuses on a portfolio of buildings, it must aim to meet the reduction targets stated above for each building.

    - **Retrofit of municipal facilities.** Combined grant and low-interest loan of up to $5 million and a grant worth up to 15% of the loan to cover up to 80% of eligible costs. This program funds projects that improve energy efficiency by at least 30% in municipal facilities with a minimum of 10% through on-site renewable energy. This funding has a two-stage application process with an Initial Review Form that can be complete and submit year-round and a sub-sequential application for potential applicants after the first stage.
    - **New construction of energy efficient municipal facilities.** Combined grant and low-interest loan of up to $5 million and a grant worth up to 15% of the loan to cover up to 80% of eligible costs. This program funds projects of initiatives that target net zero energy performance in new municipal facilities. This funding has a two-stage application process with an Initial Review Form that can be complete and submit year-round and a sub-sequential application for potential applicants after the first stage.
- **Save On Energy – Retrofit program** which is supported under the current conservation and demand management framework 2021-2024. Financial incentives are available to cover up to 50% of the project costs to a maximum of $1,000,000 for projects that provide sustainable, measurable, and verifiable reductions in peak electricity demand and electricity consumption. Projects that qualify for the Retrofit program must provide measurable energy savings which range from lighting, HVAC equipment and controls to variable frequency drives. The project must be pre-approved to be eligible.
- **IESO: Grid Innovation Fund/OEB Innovation Sandbox** which supports innovation with the potential to achieve significant electricity bill savings for Ontario ratepayers. This program will provide support up to a maximum of 50% of eligible project costs. Proponent and partner contributions must be at least 25% in cash to the total project value. Eligible projects must demonstrate the potential for cost-effective services that Distributed Energy Resource (DER) solutions can provide to consumers, distribution systems and the IESO-controlled grid to unlock ratepayer cost savings. DERs include resources such as solar panels, combined heat and power plants, electricity storage, small natural gas-fuelled generators, electric vehicles, and controllable loads, such as HVAC systems and electric water heaters.
- **Investing in Canada Infrastructure Program - Green and Inclusive Community Buildings Program (GICB).** As part of the Investing in Canada Plan, this program aims

to improve existing building by reducing GHG emissions, increasing energy efficiency, building resiliency to climate change, and encouraging new builds to net zero standards. This five-year $1.5 billion program will support green and accessible retrofits, repairs, or upgrades of existing public community buildings. Applicants with retrofit projects to existing community buildings ranging in total eligible cost from $100,000 to $3 million will be accepted on a continuous basis and funded on a rolling intake basis. All retrofit projects must be planned to be completed within the timeframe between April 1, 2021, and March 31, 2026.

Respectfully Submitted

Brad MacColluch, P.Eng.
Electrical Engineer

Jamie Baker, P.Eng.
Sr. Municipal Engineer

APPENDIX D

TM #4: Electrical Equipment Review

TECHNICAL MEMORANDUM

PROJECT: **Craigleith Main Sewage Lift Station**
DATE: November 26, 2021
TO: **Brent Rolufs, PM Town of the Blue Mountains**
FROM: Jamie Witherspoon, WT Infrastructure
RE: **Electrical Review – Equipment**

This technical memorandum is provided as a preliminary electrical design report for the planned upgrades to the Craigleith SLS. It includes a review of the existing electrical equipment within the SLS and provide recommendations for electrical upgrades to the site.

1 Existing Power Distribution

Much of the existing electrical equipment is original to the station (c. 1985) and nearing its expected design life. With planned upgrades to the pumping arrangement and ventilation systems, it is recommended that all of the existing distribution equipment be replaced rather than modified to suit the new systems. At a minimum, this will include the replacement of MCC-1, VFD-1, VFD-2, LP-A, generator and ATS. The existing utility service has sufficient capacity to support the future process upgrades however the location of the service entrance equipment will be relocated and as such, the service entrance conductors will be relocated and/or replaced as part of the distribution system upgrades. Further detail on the existing distribution equipment is provided below.

1.1 Service

The existing power supply is fed from 4.16/8.32V : 347/600V, 300kVA pad mounted transformer owned by Hydro One and located on the SLS property. Customer owned, parallel 350MCM Cu service conductors are rated for 600Amps and provide 347/600V, 3-phase, 4-wire service to service entrance breaker located within MCC-1. The service entrance breaker is rated for 600Amps but is set to trip at 300Amps which aligns with the capacity of the 300kVA transformer. Based on preliminary design expectations, there is sufficient capacity within the existing service to support planned upgrades.

1.2 MCC-1

MCC-1 houses the service entrance breaker, utility metering compartment, analog voltage and current meters, auto-transfer switch, motor starter buckets for mechanical loads and feeder breakers supplying the sewage pump VFDs. The Furnas 89 MCC lineup was purchased by

Siemens in 1995 and direct fit replacement buckets are available through Siemens current Tiastar lineup however there would be significant modifications required to the existing MCC to facilitate new digital metering, auto transfer equipment, connections to renewable energy sources (PV or other). In addition, the MCC lineup is not rated for the existing Class 1, Div. 2 environment and would require the installation of an air interlock to separate the environment from the dry well to declassify the area.

It is recommended that this MCC lineup and it's associated housekeeping pad be removed as part of the electrical upgrades. This will provide greater working space for the control panel and electrical equipment located behind the MCC as well as free up space for a proposed air-lock structure around the stairway entering the dry well. By locating the new generator outside of the building, there will be sufficient wall space available to relocate the service entrance point elsewhere.

Modern heating and ventilation systems incorporate the motors starters within the equipment and so with the planned mechanical upgrades, a future MCC would not be required.

1.3 VFDs

The existing VFDs will be replaced with modern VFDs sized for the proposed pump arrangement to optimize efficiencies. Operators have experiences VFD failures due to drive overheating during storm events. The new VFDs will incorporate well designed cooling systems to ensure reliable operation under all operating conditions.

1.4 Generator

The existing generator and controls were installed in 1999 and designed to comply with EPA Tier 1 emission requirements. Modern generators and generator control systems comply to Tier 3 emissions which require a nearly 70% reduction in CO_2 emissions vs Tier 1 designs. The existing generator will be replaced with a packaged stand-by generator unit located within a walk-in enclosure outside of the SLS building. The enclosure will incorporate a sub-base fuel tank for diesel storage.

2 New Power Distribution

Upgrades to the electrical distribution system should be included as part of the planned process upgrades at the Craigleith SLS. The new electrical distribution system will be based on the total load requirements of all equipment within the facility, and will provide system reliability, ease of maintenance and resilience.

A preliminary single line diagram (SLD) for the proposed distribution system is attached to this memorandum; the SLD (Drawing PD E1) with high level equipment specifications provided within this section.

2.1 Design Codes and Standards

The electrical design will follow the requirements stipulated in the latest edition of the Ontario Electrical Safety Code and rules and regulations, including the CEC (Canadian Electrical Code). Areas that will have a hazardous classification will be determined using the latest editions of the following standards:

- Ontario Building Code (OBC).
- NFPA 820, Standard for Fire Protection in Wastewater Treatment and Collection Facilities.
- Other applicable standards from the NFPA, CAN/CSA and TSSA (Technical Standards and Safety Authority) will also be used as a reference for the electrical design in the facility.

2.2 Electrical Service

The existing 347/600V, 300Amp electrical service from Hydro One will be reused and a new service entrance rated switchboard will be provided including a main breaker, utility metering, customer power monitoring, surge protection and provisions for incorporating grid tied solar generation with the following high-level specifications.

Switchboard

Voltage Rating: 347/600V, 3-phase, 4-wire
Bus Rating: 600 Amps
Bus Material: Copper

Acceptable Manufactures:

- Square-D QED-2 (Schneider Electric)
- Eaton Pow-R-Line C Switchboard
- Siemens SB Series

Utility Metering

A utility metering compartment will be incorporated into the new switchboard. Final dimensions and specifications to be coordinated with Hydro One.

Customer Metering

Customer power monitoring will be provided within the switchboard. The power monitor will provide the monitoring and data logging of the following parameters.

- Voltage
- Current
- Frequency
- Power
- Energy Consumption
- Harmonic Distortion

Acceptable Manufactures:

- Schneider PowerLogic PM8240

2.3 Emergency Supply

2.3.1 Generator

A new outdoor diesel generator set will be installed to provide sufficient emergency back-up power to power the entire SLS in the event of a utility power outage. The generator will be sized to provide emergency stand-by power to the entire SLS under all operating conditions. It is recommended that generator be fueled by a diesel power source with onsite fuel storage based on considerations during a disaster situation as highlighted in CSA C282. To facilitate this, the new generator will be located in an outdoor walk-in enclosure with a sub-base fuel tank incorporated into the enclosure design. A minimum 24hour fuel storage will be provided. The entire assembly will be mounted to a structural concrete slab with appropriate seismic restraints.

The Walk-in Enclosure shall be sound attenuating and will be provided with: Thermostatically controlled cooling air, supply / exhaust / bypass dampers, interior / exterior LED fixtures, electric unit heater, 24cct 120/208V panel, fire alarm pull station, fire alarm heat detector, fire alarm bell/buzzer and numerous other standard features. The generator will be located to minimize sound pollution to neighbouring properties. Additional sound attenuating barriers shall be provided as required to ensure noise levels at the property boundaries are below regulated values.

The generator will operate automatically, based on the availability of "Normal" power. The control of the generator start will be through the ATS – located in the Main Electrical Room.

Acceptable Manufactures:

- Cummins
- Caterpillar Toromont Power Systems

- Generac

2.3.2 Auto Transfer Switch

A new standalone auto transfer switch will be provided to interconnect the emergency generator supply with the normal utility supply. The transfer switch will monitor the phase voltages on the normal power supply. Upon loss of supply the ATS shall automatically initiate a start sequence on the standby generator and transfer load to the standby power source once the generator reaches stable operating limits. When normal power becomes available, the ATS will transfer the load back to the normal power supply and initiate a shut-down sequence on the standby generator. The transfer switch shall incorporate the following features:

- Rating: 347/600V, 60Hz, 600Amp, 3-pole, 4-wire with solid neutral.
- Switching mechanism shall be contactor type
- Bypass transfer mechanism shall be incorporated into the design.
- Open transition

Acceptable Manufacturers:

- ASCO 7000 Series
- Cummins BTPC Series
- Cutler-Hammer contactor based ATS c/w ATC-800 controller

2.4 Distribution

2.4.1 600V Distribution Panel

A new 600V distribution panel will be provided to distribute 600V power to the sewage pumps and larger mechanical equipment within the site. The panel will accept group mounted molded case circuit breakers (MCCBs) to provide branch circuit protection. The MCCB to include both thermal and magnetic protection unless otherwise indicated.

Acceptable Manufactures:

- Square D (Schneider)
- Cutler Hammer (Eaton)
- Siemens

2.4.2 Distribution Transformer

A 600V:120/208V dry-type distribution transformer will be provided to serve the 120V loads within the building. This transformer will be mounted on a concrete housekeeping pad with minimum 150mm clearance around for adequate ventilation. 300mm separation is required from combustible surfaces. Transformers shall include the following basic features:

- Minimum efficiencies as stated in CSA 802.2
- Copper windings with brazed or pressure type connections
- NEMA Type 3R enclosure
- Class H – 150ºC Insulation
- K-Factor Rating of 4 or higher

Acceptable Manufactures:

- Square D (Schneider)
- Cutler Hammer (Eaton)
- Siemens
- General Electric (GE)
- Hammond Power Solutions
- ABB

2.4.3 120/208V Lighting Panel

A new 120/208V Lighting Panel will be provided to serve existing 120V loads within the SLS. A 120/208V, 60Amp circuit will be provided to the new generator walk in enclosure. The lighting panel shall include factory installed, bolt on miniature circuit breakers.

Acceptable Manufactures:

- Square D (Schneider)
- Cutler Hammer (Eaton)
- Siemens

2.5 Motors

All motors with continuous duty will be of high efficiency type as required by NEMA standards.

All motors supplied from variable frequency drives (VFDs) will be inverter duty suitable for operation on variable frequency drives per NEMA MG1, Part 3.

2.6 Variable Frequency Drives (VFDs)

New variable frequency drives will be provided for the sewage pumps. It is recommended that each VFD be provided as a separately packaged unit rather than incorporated into an MCC lineup. This provides for greater flexibility in equipment layout. Final sizing and arrangement will be dependant on the proposed pump arrangement.

Each sewage pump will be provided with their own dedicated VFD with the following features.

- The output current rating of the drive shall exceed the motor full load current rating.
- The drive shall provide adjustable frequency output ranging from 30-60Hz minimum.
- The drive shall have a passive harmonic filter incorporated into the input section of the drive to reduce harmonic content and provided isolation from line side transients.
- The drive shall incorporate load side dv/dt filters to minimize load side voltage transients which can lead to premature motor insulation failure.
- The drive shall be enclosed within a NEMA 12 enclosure.
- The enclosure shall include a door mounted operator interface to provide local control of the pump including:
  - VFD HIM controller
  - Hand/Off/Auto Control Switches
  - Status Indication (Running, Fault)
- The drive shall be capable of communicating with the SLS plc via ethernet. All control signals will be hardwired. Status signals will be communicated over ethernet.
- The drive shall incorporate an appropriate enclosure cooling design to allow operation indoors in a maximum 40ºC ambient temperature. Enclosure heating is not required.
- The drive shall be assembled in a CSA certified panel shop.

Acceptable manufacturers:

- Allen Bradley (Rockwell)

2.7 Lighting

Existing fluorescent lighting will by upgraded to long life, energy efficient LED lighting. Lighting levels proposed for new building areas are as follows:

- 300 lux for indoor areas
- 1000 lux for indoor lab/office type areas
- 30 lux for all general outdoor area, 50 lux for parking lot
- 10 lux for in areas for emergency lighting

2.8 Renewable Energy Resources

A 10kW rooftop solar array could be incorporated into the electrical design. This renewable energy source would be connected in parallel with the utility supply via a grid-tie inverter. This array would couple with the utility supply at the new service entrance switchboard.

2.9 Grounding

A complete and permanent grounding and bonding system is to be included in the electrical design as per the applicable code requirements. The system shall include: a new system grounding electrode for grounding the utility service, ground rods outside of walk-in generator enclosure, 8mm x 50mm ground bus mounted on insulators on all walls of electrical rooms, ground rods connected to electrical room ground bus, inter- connection of grounds, grounding of incoming water and gas piping, tray, electrical equipment, and building steel.

2.10 Surge Protection

Industrial grade Surge Protective Devices (SDPs) will be provided at 600V and 208V distribution panels to transient voltage surge protection throughout the facility. The SPDs will be externally mounted adjacent to distribution panels with close-coupled leads to minimize impedance and improve overall protection.

Acceptable manufacturers:

- Raycap Ravoss/Strikesorb product line

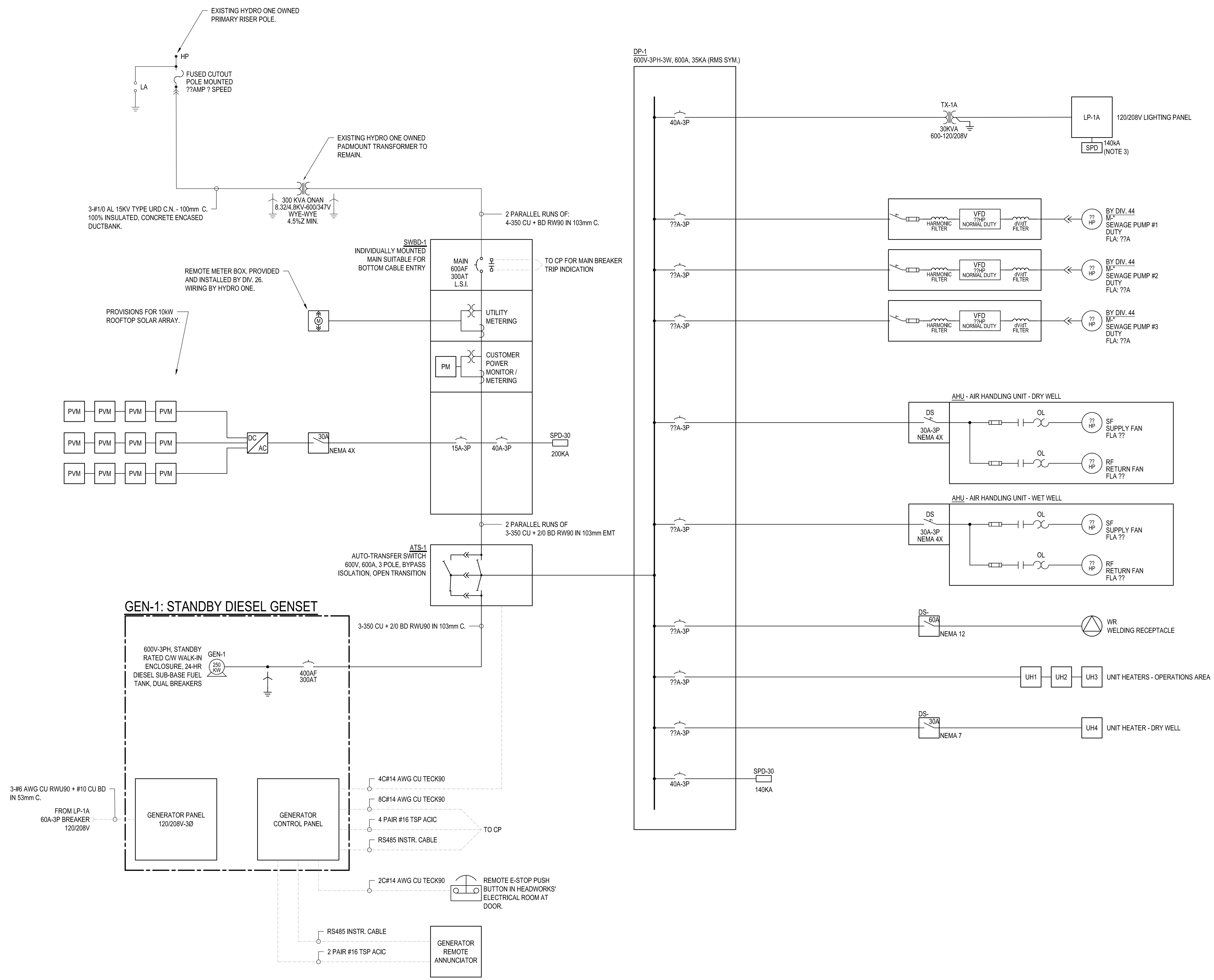
Respectfully Submitted

B. MacCulloch

Brad MacColluch, P.Eng.
Electrical Engineer

J Baker

Jamie Baker, P.Eng.
Sr. Municipal Engineer



NOTES:

1. ALL EQUIPMENT SUPPLIED BY DIV. 26 UNLESS OTHERWISE INDICATED.
2. DIV. 26 (ELECTRICAL) CONTRACTOR TO PROVIDE AND INSTALL ALL REQUIRED MOUNTING HARDWARE & WIRING FOR ALL ELECTRICAL AND INSTRUMENTATION EQUIPMENT REGARDLESS OF WHICH DIVISION SUPPLIES THE EQUIPMENT.
3. SURGE PROTECTIVE DEVICE TO BE CLOSE COUPLED TO PANEL BOARD WITH SUPPLY LEADS AS SHORT AS PRACTICABLE.

LEGEND:

XX HP	MOTOR, RATING AS SHOWN
XX KW	GENERATOR, RATING AS SHOWN
HF-?? ??HP	HARMONIC FILTER, RATING AS SHOWN
	DISCONNECT SWITCH, RATING AS SHOWN
	FUSED DISCONNECT SWITCH
	CIRCUIT BREAKER
	MOTOR CIRCUIT PROTECTOR
	THERMAL OVERLOAD
	TRANSFORMER
SPD	SURGE PROTECTION DEVICE, RATING AS INDICATED
	LOCAL CONTROL STATION. SEE MOTOR CONTROL SCHEMATICS FOR WIRING DETAILS.
EYS	EYS SEAL
	CABLE SPLICE

ABBREVIATIONS:

C/W	DEVICE SUPPLIED COMPLETE WITH LEAD CABLE
PB	PULL BOX, SIZED TO SUIT
SB	SPLICE BOX, SIZED TO SUIT
TSP	TWISTED SHIELD PAIR

DATE	No.	REVISION

EVB ENGINEERING
800 SECOND STREET WEST
CORNWALL, ONTARIO CANADA, K6J 1H6
TEL: 613-935-3775 | FAX: 613-935-6450
WEBSITE: EVBengineering.com

CLIENT:
TOWN OF THE BLUE MOUNTAINS

PROJECT:
CRAIGLEITH WASTEWATER PUMPING STATION

TITLE:
PRELIMINARY SINGLE LINE DIAGRAM (NEW)

SCALE: N.T.S.	JOB NO: 21178
DESIGNED BY: J.E.S.	DATE: YY/MM/DD
DRAWN BY: B.A.M.	DRAWING NO. PD.E1
CHECKED BY: J.E.S.	

APPENDIX E

TM #5: Process Control Narrative

TECHNICAL MEMORANDUM

PROJECT: **Craigleith Main Sewage Lift Station**
DATE: January 28, 2022
TO: **Brent Rolufs, PM Town of the Blue Mountains**
FROM: Jamie Witherspoon, WT Infrastructure
RE: **Process Control Narrative – Existing and Proposed**

This technical memorandum is provided as a preliminary electrical design report for the planned upgrades to the Craigleith SLS. It will include a review of the existing process control narrative as it relates to the current pumping operations and provide recommendations for any changes/upgrades to the system controls as part of the upgrades to the site. Not included in this review are controls for auxiliary systems within the SLS such as building ventilation or emergency back-up power systems.

1 Existing Control Narrative

1.1 System Overview

The Craigleith SLS receives raw sewage from the Town's wastewater collection system and pumps it to the Craigleith WWTP. Raw sewage enters the SLS within the wet well portion of the station. Two (2) 100HP sewage lift pumps located within the drywell pull the raw sewage via suction lines into the wetwell and discharge it through a force main supplying the WWTP. The sewage lift pumps are powered through variable frequency drives (VFDs) which allows for flow control on the discharge piping. Under normal conditions, the PLC at this location is the primary device controlling the pumps. The discharge flow rate is regulated based on the level within the wetwell and generally matches the inflow rate. The current pump configuration and setpoints are such that at least one pump runs continuously (>99% of time) throughout the year.

A series of floats provide backup control in the event of a PLC failure.

1.1.1 Wetwell Arrangement

Figure 1 below depicts a cross section of the existing wetwell at Craigleith SLS. The wetwell is partitioned to form a "North well" and "South Well". An interconnecting isolation gate is provided within the partition wall allowing operators to isolate half of the wetwell for maintenance purposes while maintaining flow through the station through the alternate wetwell. Under normal operating conditions, the partition gate remains open, and the system operates as if it were one large wetwell.

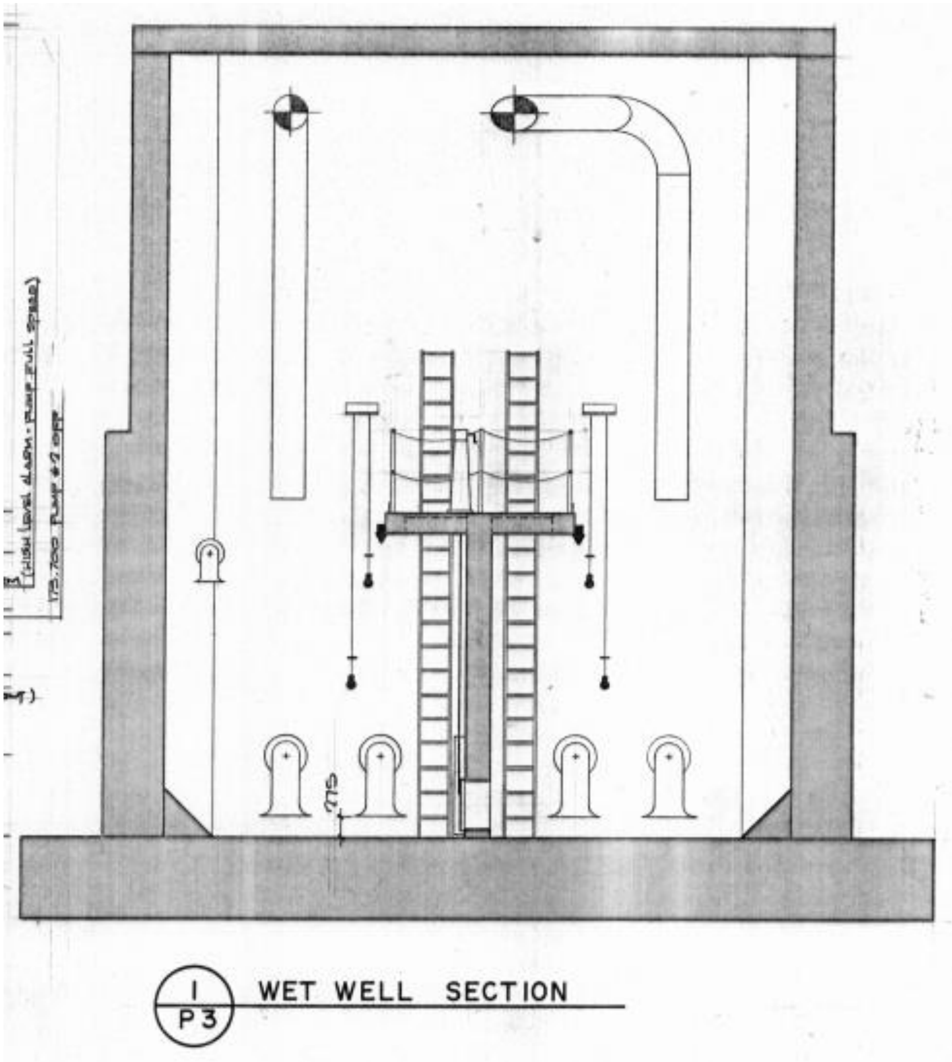


Figure 1 - Wet Well Arrangement

1.1.2 Instrumentation Arrangement

Level elements are provided within the wetwell to provide continuous measurement and monitoring of the wet well levels for automatic control of the sewage lift pumps. An ultrasonic level element is installed within the North well and a hydrostatic pressure element is installed within the South well. This allows for redundant level measurement within the wetwell. Operators can select which element they would like to use to control the pumps.

High-Level and Low-Level floats are provided within the North and South wells to provide backup operation of the pumps. Each pair of floats are wired in parallel to provide redundant control from either the North or South well.

1.2 Modes of Operation

There are three basic modes of operation at the lift station as follows:

1.2.1 Local Manual Control

Operators can control the sewage lift pumps directly via the HMI controls at each VFD by switching an individual pump into local control via selector switch. This allows the operator to start or stop the pumps as desired as well as adjust the drive output frequency to manually control the pump flows. Remote control, whether manual or auto, would be blocked when operating in this control mode allowing operators to fully drain the wells beyond any float limits. Operators would need to manually verify wet well levels to ensure the system is operating within its limitations.

Barring a local PLC failure, all wetwell alarms would remain active when this mode is selected.

1.2.2 Remote Manual Control

Remote manual control allows operators to control the station via remote interfaces. At Craigleith, this can be done via any workstation on the SCADA network. System operating conditions and levels would be made available via SCADA control screens to allow remote operators to make appropriate manual adjustments to the system.

Operators can place the system into Remote manual operation via the SCADA screen.

1.2.3 Remote Auto Control (PLC with Float Backup)

Normal Operation (PLC Control)

Under normal operation and flow conditions, the pumps operate in a lead-lag arrangement where only one of the sewage pumps is operating concurrently (lead pump). The pumps will alternate between lead/lag pump on a 2-1 duty cycle where pump P2 will operate as the lead pump for 48hours before switching over the lead pump duties to pump P1 which will then operate as the lead pump for 24hours and so on.

Level elements within the wetwell monitor the current level within the wetwell. When all pumps are off and the level rises above the “Lead_Pump_Start” setpoint, the designated lead pump will start. The pump speed/flow is automatically controlled by the PLC within the SLS control panel. A proportional control loop is programmed into the PLC which will increase the pump speed as the level in the wet well rises to a maximum speed setpoint (95%) and reduce the pump speed as the level in the wet well falls to a minimum speed setpoint (34%). With this arrangement, the pump flow will generally match the inlet flow into the SLS. The pump speed is calculated as:

Speed = kp * (Current_Level - Control_Level) / 100 + Min_Speed

If the lead pump is unable to keep up with the flow into the SLS the level within the wet well will rise until it hits a "lag_pump_start" setpoint. At which point, the designated lag pump will start up to assist in lowering the level within the wet well. The lag pump speed is controlled by an identical proportional control equation with its own setpoints. Both pumps will remain in operation until the level in the wetwell drops below a "lag_pump_stop" setpoint at which point the lag pump will turn off and only the lead pump will remain running. The lead pump will continue to operate until either the level drops below the "lead_pump_stop" setpoint or the duty controller alters the pumps duty status.

The inlet flows into the SLS typically stay at or above the minimum pump flow and so the lead pump generally operates on a continuous basis.

The following Table 1 outlines the pump control setpoints as referenced from the bottom of the wetwell.

Table 1: Pump Control Setpoints

Setpoint	Value	Lead Pump Speed (%)	Lag Pump Speed (%)	Comments
Low Level Float (Alarm/Stop)				
Lead_Pump_Stop	1450mm	34%	0%	
Lead_Pump_Start	1600mm	34%	0%	
Lead_Pump_Control	1600mm	34%	0%	Lead Pump Min Speed
Lag_Pump_Control	1700mm	56%	34%	Lag Pump Min Speed. Lag Pump wouldn't operate at this point since it is below lag_pump_stop setpoint.
Lag_Pump_Stop	1850mm	89%	67%	
Lead_Pump_Max_Speed	1877mm	95%	73%	
Lag_Pump_Start	2000mm	95%	78%	
Lag_Pump_Max_Speed	2000mm	95%	95%	
High Level Float (Alarm/Stop)	3100mm	100%	100%	

Float Backup Mode

High- and Low-level floats are provided within the wetwell to provide backup control of the pumps in the event PLC or other failure to the automatic control system. Redundant floats are provided at both the high and low level setpoint. Each set of floats are wired in parallel, and so either float could initiate the backup control mode.

If the level within the wet well reaches the high-level float (Pump Start), a high-level alarm will be initiated and both pumps will run at 100% speed until the level reaches the low-level float (Pump Stop) at which point, both pumps will stop, and the system will reset to attempt automatic control via the PLC.

1.3 Issues/Concerns

Although not directly related to the existing control scheme, the existing pump arrangement leads to reliability and system efficiency concerns as addressed under separate convers. A new pump arrangement scheme is proposed and so alterations to the process control narrative are required to fit the new pump arrangement while optimizing system reliability, user operability and system efficiency.

2 Proposed Control Narrative

2.1 System Overview

As part of the proposed upgrades to the Craigleith SLS, the existing sewage lift pumps and associated VFDs will be removed and replaced with three or four new lift pumps with each having their own dedicated VFD. This will increase system reliability and operational efficiencies under all flow conditions through the station.

2.1.1 Wetwell Arrangement

The wetwell arrangement will remain as is with a North and South well separated by a partition wall and isolation gate. Operators will be able to isolate half of the wetwell for maintenance and inspection activities while maintaining flow through the station.

2.1.2 Pumping Arrangement

The new pumping arrangement could include:

- Two (2) raw sewage lift pumps (lead/lag) with VFDs
- Two (2) lag raw sewage lift pumps (1 lag + 1 standby) with VFDs to serve as wet weather flow pumps

2.1.3 Instrumentation Arrangement

The existing instrumentation will be replicated with the proposed upgrades at the SLS including one level element in each half of the wetwell. Including both an ultrasonic and hydrostatic element has become common practice and provides reliability from both a redundancy and technology perspective. It is recommended that the floats be replaced with Multitrode level controllers mainly due to the failure and unreliable nature of the float switches. The Multitrode unit operates as a discrete level sensor, generally replacing the float switches in many municipalities, which operate similar to a hydrostatic element.

2.2 Modes of Operation

There will continue to be three basic modes of operation at the lift station as follows:

2.2.1 Local Manual Control

Operators can control the sewage lift pumps directly via the HMI controls at each VFD by switching an individual pump into local control via selector switch. This allows the operator to start or stop the pumps as desired as well as adjust the drive output frequency to manually control the pump flows. Remote control, whether manual or auto, would be blocked when operating in this control mode allowing operators to fully drain the wells beyond any instrumentation control limits. Operators would need to manually verify wet well levels to ensure the system is operating within its limitations.

Barring a local PLC failure, all wetwell alarms would remain active when this mode is selected.

2.2.2 Remote Manual Control

Remote manual control allows operators to control the station via remote interfaces. At Craigleith, this would be done via any workstation on the SCADA network. An operator interface terminal (OIT) would be provided within the stations control room for remote manual control as well. System operating conditions and levels would be made available via SCADA control screens to allow remote operators to make appropriate manual adjustments to the system.

Operators will be able to put the system into remote manual control via the SCADA interface.

2.2.3 Remote Auto Control (PLC with Backup)

Normal Operation (PLC Control)

Under normal operation and flow conditions, lead pump P1 and lag pump P2 will operate in a lead-lag arrangement. The pumps will alternate between lead/lag pump on an operator adjustable interval, timed for uneven pump run-time or as desired by operations.

Level elements within the wetwell will monitor the current level within the wetwell. When all pumps are off and the level rises above the “Lead_Pump_Start” setpoint, the designated lead pump will start. The pump speed/flow will be automatically controlled by the PLC within the SLS control panel. A proportional control loop will be programmed into the PLC which will increase the pump speed as the level in the wet well rises to a maximum speed setpoint and reduce the pump speed as the level in the wet well falls to a minimum speed setpoint (TBD). With this arrangement, the pump flow will generally match the inlet flow into the SLS.

If the lead pump is unable to keep up with the flow into the SLS the level within the wet well will rise until it hits a “lag_pump1_start” setpoint. At which point, the designated lag pump will start up to assist in lowering the level within the wet well. The lag pump speed is controlled by an identical proportional control equation to the lead pump. When the lag_pump1_start setpoint is reached, both pumps will be operating at maximum speed. Their speed will decrease until a balance point is reached within the proportional control equation. Both pumps will remain in operation until the level in the wetwell drops below a “lag_pump1_stop” setpoint at which point the lag pump will turn off and only the lead pump will remain running. The lead pump will continue to operate until either the level drops below the “lead_pump_stop” setpoint or the duty controller alters the pumps duty status.

During storm events, it is possible that the inlet flows into the SLS will exceed the capacity of both the lead pump and lag pump1 operating in parallel. In this situation, the level within the wetwell will rise until it reaches a lag_pump2_setpoint. At this point, the second lag pump will start and after an adjustable time interval all other pumps will turn off. The speed of the second lag pump will be controlled on a proportional control loop based on the level within the wetwell. As the impact of the storm event resides, the level within the wetwell will drop until it reaches a lag_pump2_stop setpoint and the entire process will reset.

The following Table 2 outlines the preliminary pump control setpoints as referenced from the bottom of the wetwell. Values will be finalized as part of the detailed design. The main goal of the lead pump set points is to provide as much wet well depth as possible to allow the pump sufficient range to respond to variations of inflow prior to the lag pump being called into operation.

Table 2: Preliminary Wetwell Control Levels

Setpoint	Value
Low Level Float (Alarm/Stop)	1200mm
Lead_Pump_Stop	1300mm
Lag_Pump2_Stop	1300mm
Lag_Pump1_Stop	1450mm
Lead_Pump_Start	1600mm
Pump_Control_Level	1600mm
Lag_Pump1_Start	1900mm
Lag_Pump2_Start	2050mm
High Level Float (Alarm/Stop)	3100mm

Backup Mode

High- and Low-level alarm/controls signals will be initiated by the Multitrode within the wetwell to provide backup control of the pumps in the event PLC or other failure to the automatic control system. Redundant Multitrodes will be provided in both the North and South wetwell. Each set of control signals are wired in parallel, and so either float could initiate the backup control mode.

If the level within the wet well reaches the high-level setpoint (Pump Start), a high-level alarm will be initiated and the standby pump will start and run at 100% speed until the level reaches the low-level float (Pump Stop) at which point, the second lag pump will stop.

APPENDIX F

TM #6: Septage and Leachate Receiving Station

WT INFRASTRUCTURE
PRACTICAL INNOVATION

MEMORANDUM

To: The Town of Blue Mountains

From: Jamie Witherspoon, P.Eng.

Date: February 25, 2022

Re: 21-2028 – Craigleith Wastewater Pumping Station - Mechanical & Electrical Optimization

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The following memorandum is intended to be an interim update to review and identify the potential impacts related to the disposal of leachate and septage at the Craigleith Wastewater Pumping Station. This information will be integrated into the final project report.

Existing Receiving Station

The existing septage and leachate receiving station was added to the Pumping Station in 2009 and it is located at the western exterior wall of the facility. In particular,

- **The septage receiving station** is characterized by an analog screen data logger and control panel, a 100 mm diameter pipe with an electric actuated valve, magnetic flow meter and wall-mounted transmitter.
- **The leachate receiving station** is characterized by a 150 mm diameter pipe, without controls or flow measurements.

A review of background information suggested that the volume of septage is approximately a third of the volume of leachate. Specifically, the pumping station receive between 283 m^3/month to 1,553 m^3/month of septage, and 635 m^3/month to 5,506 m^3/month of leachate.

Both the septage and leachate are discharged through hatches into the wet well where a channel monster grinder is installed.

Challenges with the Existing Receiving Station

The following are the main challenges associated with the septage and leachate receiving station at the Craigleith Pumping Station:

1. **<u>Access to the facility</u>**

   The existing Craigleith Main Lift Station is an exterior station located proximate to both current and future residential properties and near to the Highway 26 in a location where septage hauling vehicles need to complete relatively complex movements to navigate the site. Background information suggested that approximately 700 round trips are made annually by the haulage trucks to the Craigleith Pumping Station which results in a significant amount of traffic in the area. The truck traffic also impacts the Georgian Trail crossing in the vicinity of the facility. Furthermore, as the residential area to the south of the Craigleith pumping station is expected to increase, the truck traffic for the disposal of leachate would be a source of logistic difficulties in the area.

2. **<u>Odour complaints.</u>**

Septage has an offensive odor, and septage processing can release odors in the atmosphere. As the facility is designed to receive septage and leachate, given the current proximity of houses, this activity resulted in an increase in odour complaints. Although attempts have been made to reduce the odour and associated complaints, there has been limited success with aeration and chemical treatments. Due to the expected growth of residential units to the south of the pumping station, it is anticipated that the amount of odour complaints would increase.

3. **<u>Operational challenges.</u>**

Operational challenges related to the treatment and disposal of septage and leachate at the facility are mainly related to:

- *<u>Treatment operation and maintenance:</u>* The strength of raw septage in comparison to raw domestic sewage is one of the biggest challenges to face during treatment. Indeed, septage contains significant levels of grease, scum, grit, rocks, rags, plastics and other debris. The high solids content causes significant ragging and subsequent downtime of pump and treatment equipment while the high concentrations of nutrients may cause corrosion in the pipes and processing equipment. Cleaning and maintaining process equipment is fundamental. However, the existing receiving station does not have means to remove rocks, large debris and rags which cause problems with operation of the grinder and clog the sewage pump impellers. Periodically, the grinder unit is removed from the wet well and shipped to the manufacturer for replacement of its grinding parts. Removing and reinstalling the grinder is time consuming and costly. Pump impellers have been replaced frequently. Both pumps need to be taken out of service on a regular basis for maintenance.
- *<u>Inability to balance flow into the system:</u>* The bulk delivery of leachate in large truck load quantities at the facility does not allow for good mixing and dilution of the waste. Furthermore, in the past years, both the Town’s wastewater treatments plants have been negatively impacted to the delivery of leachate in truck load quantities to the point of threatening the Town’s ability to maintain compliance with the Plants’ Environmental Compliance Approvals. As leachate from "young” wastes is characterized by high chemical oxygen demand (COD) and biological oxygen demand (BOD) values (and by high ratios of BOD to COD), low pH and initially high in metals, the delivery of leachate in truck load quantities creates a situation where the Plant’s biology is impacted due to the shock loading of high strength wastewater.

Potential Solutions

As the existing facility is facing the aforementioned challenges, alternative solutions to overcome current problems must be considered. Options that should be considered include:

1. Mixing and balancing flow to minimize spikes.
2. Enclosed off-loading area.
3. Ventilation/odour control to minimize off-site impacts.

In order to achieve mixing and flow balancing at the existing system, there are two primary options that could be considered. The first option would be to install a balancing tank and pumping system to pace flow into the pumping station to reduce the shock loading to the treatment facility. The second option would be to provide mixing and pump controls to allow for the intentional dilution of the septage in the wetwell to reduce the shock loading at the plant. Both of these alternatives will increase the residency time of septage and leachate at the pumping station and may result in more significant odour.

Enclosing the off-loading area would allow for improved odour control and more effective year round operation. At this site, due to the limited available space, a drive through enclosure is not likely feasible. Therefore, a back in enclosure could be considered. This would result in safety concerns associated with vehicle movements. The provision of an enclosure would allow for improved odour management by centralizing air collection.

If the septage and leachate receiving station remains at the pumping station, with increased flows, odour will be a more significant and potentially frequent concern. Therefore, an active odour control system may be the only feasible solution to manage the odour risk around the facility. While a well designed odour control system can address potential odour concerns, an active system can have failures resulting in odour complaints and loss of confidence

In Table 2, the option of moving the existing septage receiving station to the Craigleith Wastewater Treatment Plant have been assessed against the ability to overcome the identified challenges and related to access to the facility, odour complains, treatment operation and maintenance.

Table 1: Assessing the Impacts of Relocating the Septage and Leachate Receiving Station

	Maintain the Receiving Station at the Craigleith Pumping Station	Relocate the Receiving Station at the Craigleith WWTP
Access to the facility	High Impact. As the residential area to the south of the Craigleith pumping station is expected to increase, the truck traffic for the disposal of leachate would be a source of logistic difficulties in the area.	Low Impact. Septic and hauled waste truck traffic will be eliminated from the developing urban area to the South of the Craigleith Pumping Station. The Craigleith WWTP is in a location where the trucks waiting in que will not be a source of logistic difficulties and community complaints.
Odour Complaints	High Impact. Due to the expected growth of residential units to the south of the pumping station, it is anticipated that the amount of odour complaints will increase.	Low Impact. The Craigleith WWTP is better located as the residential neighbours is away from the plant, thus reducing the risk of odour complaints.

Treatment operation and maintenance	High Impact. As the existing receiving station does not remove large debris and rocks, this causes significant ragging and subsequent downtime of pump and treatment equipment which increases maintenance and operational costs of the equipment. The bulk delivery of leachate in large truck load quantities at the facility does not allow for good mixing and dilution of the waste.	Low Impact. This solution will allow to deliver leachate at a steady and continuous rate thus reducing the leachate's impact on the Plant by allowing greater mixing and dilution. There is the potential for plant upset if septage addition is not properly controlled.

Conclusions

The Craigleith septage and leachate receiving station is an exterior station located proximate to both current and future residential properties and in a location where septage hauling vehicles need to complete relatively complex movements to navigate the site.

In the past years, truck traffic, odour complaints, and treatment operations challenges have been identified as consequence of the disposal of septage and leachate at the Craigleith Pumping Station.

The options considered to improve the current challenges would include:

- Mixing and balancing flow to minimize spikes.
- Enclosed off-loading area.
- Ventilation/odour control to minimize off-site impacts.

The existing septage and leachate receiving station is in a location that does not provide the conditions to overcome the identified challenges. A preliminary analysis of the Craigleith Wastewater Treatment Plant suggested that relocating the Craigleith septage and leachate receiving station to the Craigleith Wastewater Treatment Plant would provide significantly more flexibility in terms of safety, operational control, reduced impacts on adjacent residents.

This is being addressed as part of another project under the Long Point Road Class EA Project.

WT INFRASTRUCTURE

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